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Design and Construction of Experimental Stool for Tension and Compression of Springs

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A B S T R A C T

There are numerous applications for springs in engineering, including the suspension system of automobiles, IC engine valves, brakes, clutches, weight measurements, energy storage in shock absorbers (such as spring type accumulators), hydraulic components (such as hydraulic cylinders, pressure relief valves, flow control valves, etc.), and many more. But based on our market research and observations, it appears that sometimes the springs used in the aforementioned applications have a number of flaws, including manufacturing and processing flaws that sometimes result in more hardened springs with greater strength and other times result in springs with lower stiffness values. As a result, these flaws affect the applications of the springs for proper uses and the functionality of that machine. By taking into account this issue, it becomes simple and inexpensive to measure spring thickness with this equipment. This project's main goal is to calculate the spring stiffness under different loads. Spring testing kit refers to the equipment that has been integrated into a machine to stretch or compress test springs while measuring load and displacement. It investigates the properties of springs and is useful in mechanical workshops..

Keywords: Spring, Stool, Tension. Compression

Introduction

Technology is largely advancing and staying up to date to catch-up with latest innovation appears to be difficult due to the ever dynamic scenario playing out in technological world today. Electro-mechanical systems are rapidly replacing classical mechanical systems. While, both classical mechanical and electro-mechanical systems are expected to provide precision and accuracy in their operation, achieving this may be challenging. However, by testing each component prior to final assembly of the system can help in achieving desired precision and accuracy. As an example, a typical mechanical component that needs to be tested before its final assembly is spring. This is because the stiffness of spring being the most important feature seems to vary with respect to application due to its elastic nature which deforms when load is imposed on it. Therefore, since springs are designed to deform under load and with energy absorbed or released accordingly, test performance on this component of mechanical or electro-mechanical system becomes even more necessary. For instance, for coil springs, series of variable loads tests are performed by literally bouncing it to and fro in along vertical plane for a given time duration at high speed to determine its stiffness quality (Ayodeji et al., 2015). The principle used in designing and developing of spring testing machine is based on the rapid vertical oscillation that produces vibrations resulting in frequency.

Usually, made of steel, small springs can be wound from pre-hardened stock, even as the larger ones made from annealed steel and are hardened once fabricated (Tanvar, 2014).

There are many uses of springs as regards machine such for reducing, absorbing or controlling energy because of shock or vibration; for example, spring used as shock absorbers and vibration damper in car. For applying forces; for example in brakes and spring loaded valves in an automobile. For measuring forces in spring design.

Several related work regarding design of spring enabled testing system have been carried out. A spring load testing and separating system consisting of a circular table that have six workstations with a master controller and four slave controllers that take responsibility for all functions of the system was presented by Jian & Taibei (2011). A digital spring stiffness testing machine comprising hydraulic cylinders of different diameters interconnected by same liquid was designed by Jadhav et al. (2014). A testing system consisting of a frame, load cell and a scale and with a spring placed on angle plate bar, which was designed for stiffness of springs (tensile and compression) measurement by Abu Rahat et al. (2015). E-poxy glass materials were used for helical spring design in Musthak and Madhavi (2013). Harmonic analysis of helical suspension spring was done by Waghade et al. (2014). A survey study on fundamental stress distribution, characteristic of helical coil springs was carried out by Valsang (2015). In the study by Kobelev (2015), shape optimization of helical compression springs was performed.

The goal of this paper is to design and fabricate an experimental stool for tension and compression springs. Other specific objectives are to test the stiffness of the spring for high accuracy and precision, and to design and fabricate a spring stiffness test rig that can used to test various types of springs of different height, diameters, and materials. The significant of the study is that it helps to solve the problems of checking springs stiffness. The machine can be used in material testing laboratory as compression and tensioning machine.

Research methodology

Material

Some of the materials used in this the construction include iron sheet, D.C. motor, digital scale, gear, power screw, mechanical spring, frame, miscellaneous e.g. screws, nuts, soldering wire, electrolyte and others.

The materials/tools used in the design and fabrication process for the spring testing machine are lathe, drilling machine, welding machine, hand grinding/cutting disc machine, table shear, scriber and marking chalk, centre punch, dividers, venier caliper steel rules and tape, plumb /spirit level, mallet, drill bits, spanners (flat, ring, adjustable), fillers, files (square, round), painting iteming (cup, brush and sandpaper/emery cloth), hand gloves, hand shield, safety boots and wear, D.C. motor, digital scale, gear, iron sheet, power screw, mechanical screw, frame and others .

Design method

This subsection presents the steps followed in the fabrication and project schedule plan shown in Table 1.

- The angle bar was first cut into the requires dimensions for the framework
- The framework is welded together and the chips completely file off, so as to have a smooth and clean job.
- The 1 HP motor was carefully attached onto the framework with a spur gear attached to the motor shaft.
- The second gear is attached to the power screw before forcing it into an already machined casing tacked onto the framework.
- The two gears are aligned properly to initiate movement between the driver and driven gear.
- Weld the bearing casing into the required position.
- Tension and compression plates are installed into the slide rod and the power screw.
- Sandpaper and file the whole work. Do some finishing touches before painting.
- A digital scale and display are attached for taking measurements and readings.

In designing this project, solid works software and design drawing were used. The software design drawings are shown in Fig.1 to 3.

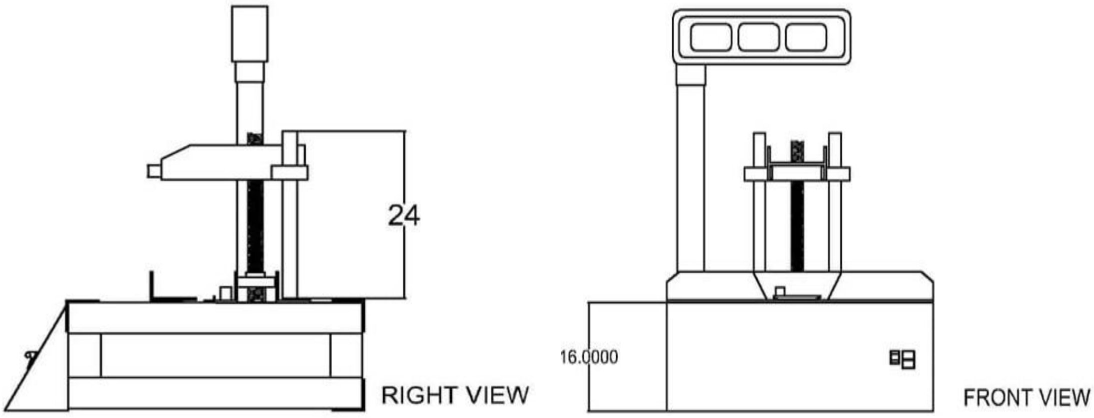

Fig. 1 - (a) Right view; (b) Front view of the design drawing of testing apparatus

Fig. 2 - (a) Compression sensor; (b) Compression and tension plates of the design drawing of testing apparatus

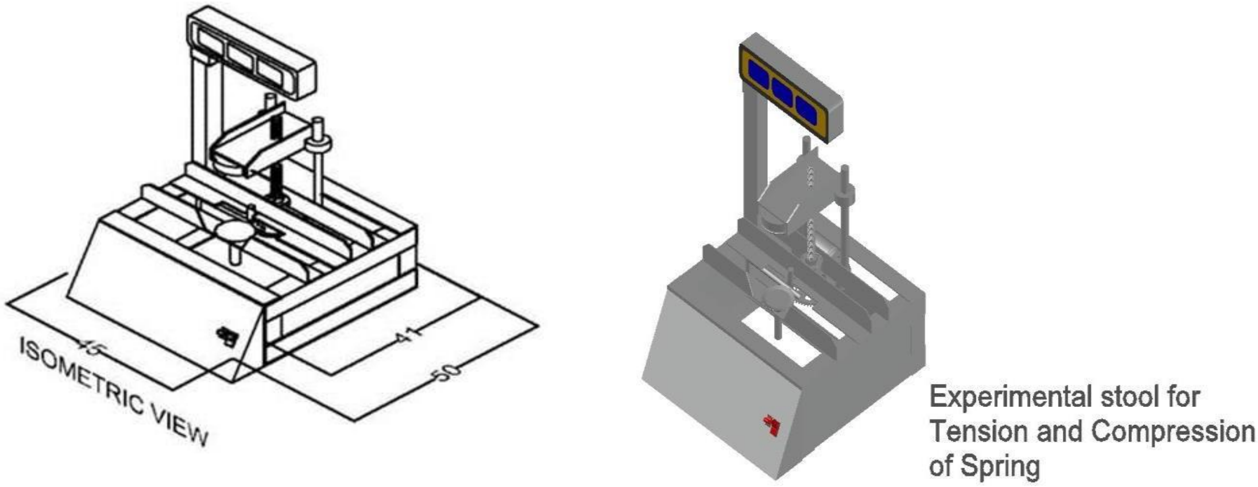

Fig. 3 - (a) Isometric view of the design drawing of testing apparatus; (b) Software design tool

Gear Design: The type of gear or arrangement of gear employed in the paper is simple gear train in which there is one gear on the motor shaft and another in the drive shaft. This method of gear drive was used because of its compact layout transmission of velocity ratio and its efficiency.

Given the pitch diameter (D) = 7mm

Number of teeth (N_2) = 34

Circular pitch (P_c) = 6.47mm

Diameter of pitch (P_d) = 0.48/mm

Outside diameter (Do) = (N_2 + 2) ÷Pd = (34 + 2) 0.48 = 17.28mm

Pressure angle = (7÷17.28) = 0.41°

Base circle diameter (D_b) = D × Cosθ = 7Cos (0.41°) = 65.35mm

Base pitch (P_b) = Pc × Cosθ = 6.47 Cos 21° = 7mm

Tooth thickness = Pc÷2 = 6.47÷ 2 = 3.35

To obtain the tangential 'tooth load' using power transmitted and pitch line velocity

WT = (P ÷ v) × Cs

Where Wt = Permissible tangential tooth load in Newton

P = Power transmitted in watts

V = Pitch line velocity in m/s =πDN/60

D = Pitch circle diameter in meters

Cs = Service factor

$V = \pi DN/60$

$(\pi 0.07 \times 2700) \div 60 = 9.89 m/s$

Ns = Speed in r.p.m

P = 746 watts

Cs (from table of y) = 1.25 (medium stock, intermittent)

Here $W = (746 \times 1.25) \div 9.896 = 94.22$ Newton

Table 1 – Project schedule plan

Process	Duration
Collection of literature	One week
Study of literature	One week
Analysis of proposed scheme	One month
Preparation of scheme/model	One month
Implementation of scheme/model	One month
Analysis and simulation	One month
Result formulation	Two weeks
Final write up and thesis submission	Two weeks

Experimental procedure

The procedure for the experiment conducted on the designed machine involves connecting the test equipment to the alternating current (AC) supply, put on the control switch, use the upward and downward motion switch to set the tensional compression plate, measure the free length of the spring, insert spring, use the upward and downward notion switch to tension and compress the spring, stop at 5 s interval, measure and record the force of tension or compression and the new length of the spring.

Results and discussion

The designed and fabricated machine is shown in Fig. 4. The results obtained from the experimental test conducted on the system presented in Table 2. Free length of spring = 70 mm. Time interval = 5 s. Hooke's law:, F = -Kx, F is the upward force the spring exerts and opposite in direction to added weight (W), x is the distance by which the spring is stretched, and the negative sign indicates that x and F are in opposite direction. The graph of extension against force is shown in Fig. 5.

Fig. 4 – Designed and fabricated spring test apparatus

Table 2 – Experimental results

S/N	Weight (equipment reading)	Force of extension x10 (N)	Extension (mm)
1	0.05	0.50	72
2	0.27	2.70	74
3	0.63	6.30	76
4	0.99	9.90	79
5	1.42	14.20	83
6	1.88	18.80	86

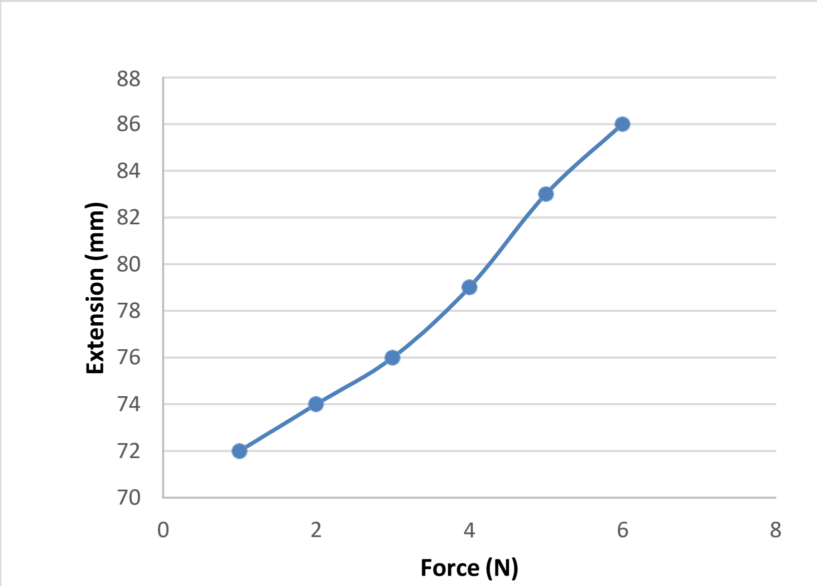

Fig. 5 – Graph of extension against force

The experimental stool for tension and compression of spring constructed consist of the following component namely: The motor, the gears, the slide rod, bushings, threaded shaft, tension and compression plate, and display unit, control switch, nuts and bolts. The system has an overall length of 550mm, width of 510mm, and a height of 150mm. The motor was a 1 Hp or 746 watts type of motor. The structural frame was made with 18 gauge iron sheet. A spur gear made of mild steel is attached to the 1 HP motor and aligned to the power screw or threaded shaft which has the driven gear attached to it to transmit force which moves the tension and compressed plate. The slide rods are installed close to the compression and tension plates for additional support with the help of bushings for the intended continuous upward and downward movements. A measuring scale was coupled under the casing and its display extended out to facilitate taking of readings. All the components of this system are systematically assembled and are carried by a robust structural frame work.

4. Conclusion

The experimental stool for tension and compression of springs presented can be used in material testing laboratory as compression and tension machine. It can as well be used in spring manufacturing industries quality checking. Furthermore, in educational institute, this machine can help to compare theoretical design and practical spring compression and tensioning.

Acknowledgements

An example appendix

The construction process is shown in Fig. A1

Fig. A1 Construction process in mechanical workshop

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