SAMPLE LABORATORY REPORTS

The sample reports in this chapter are based on the types of reports that are expected for this course and the types of reports which students actually write. Please take a few minutes to look them over, taking note of how the recommended format was used and how the facts and ideas were presented. Also, look for the errors, as if you were grading your own report or reviewing the report of a colleague or employee. And look for the good points. Were the concepts and results presented in a clear and concise manner? Was the level of detail about right or was the report too detailed. Was all of the material relevant? What was your overall impression of the report? Which author would you be more inclined to hire?

Both reports are written for the same hypothetical experiment, as if these were the reports submitted by two students taking this course. Note that both are organized exactly as recommended in the guidelines for the report format with each section clearly identified using a header. Also, the text formatting is simple, the authors having resisted the temptation to much spend time on distracting cosmetic enhancements. Both also contain common types of conceptual, grammatical and typographical errors. The most important differences in these reports, however, is in how well they actually communicate to the reader the reasons for doing the experiment, how the experiment was done and what was learned.

Evaluations of the Sample Reports
After reading the following evaluations of the sample reports read the reports and see if you can agree with the critique which appears after the report.

The figures and tables mentioned in these sample reports and the numeric values of various measured and computed quantities are not yet available. These will be added in a future version of this manual. Meanwhile, refer to the next two sections to see how figures and tables should be presented.

(Sample Report 1)

THE SPRING CONSTANT LABORATORY EXPERIMENT

Author's Name
Course Number and Name
Institution and Campus
Date: (date submitted)

Abstract

The purpose of this experiment was to measure the Spring Constant of a suspension spring. We tested the spring using the Instron universal testing machine. The Spring constant was found to be xx kN/m.

Introduction

The Spring Constant of a spring determines its resistance to stretching by the application of a load. In other words, if you load a spring, it will become longer and if you know the value of the spring constant you can predict how long it will stretch.

The purpose of this experiment is to measure the spring constant of a Spring which came from the suspension of a Volvo car. Also, we will learn how to use the Instron universal testing machine. In the end we will really know how a spring works.

Procedure

The Spring used in this experiment was from the rear suspension of a Volvo. The TA bought it at a junk yard. We measured it and found that its height was xx cm, its outer diameter was xx cm.. During the test we planned to measrue its height as the load was applied.

The test was done using the Instron universal testing machine. The Spring was placed under the crosshead which was programmed to load the spring at a rate of 10 cm/min and after reaching a point where the load was maximum the crosshead was moved upward at the same rate until it stopped at the original starting point. The data was stored on disk for futher analysis using a computer and a spreadsheet program.

Results

The graph obtained from the Instron universal testing machine shows that the line is straight. From this line we calculated the Spring Constant as

$$k = \frac{\Delta P}{\Delta x} = \frac{y}{x} = xx.xxx \text{ kN/m} \quad \textbf{(1)}$$

One can see that this number is very high meaning that the Spring is very stiff. This makes sense since the spring is from and automobile which must support high loads plus forces from bumps on the roads.

Discussion

Springs used in autombile suspensions must be very stiff and strong. Many cars weigh over 2000 pounds and must travel over 100,000 miles. These results can be used to estimate how stiff to make a Spring for any car. Assuming the Volvo is an average car then the stiffnes of the suspension springs can be calculated as

$$k = \frac{w}{2000} k_{Volvo} \tag{2}$$

where w is the weight of the car and k_{Volvo} is the Spring Constant measure in this laboratory.

Another interesting thing about the spring constant is that it is very similar to Young's modulus. When you load a piece of steel, for instance, it stretches but as soon as you take off the load it returns to its original length, just like a spring. Also, if you load the piece of sttel too much it becomes permanently deformed and does not return to the original length when the laod is removed. This also happens to springs when too much load is applied.

Conclusions

We learned a lot by doing this experiment. Springs are stiff and Instron machines can be used to measure the stiffness by compressing it. An engineer also has to consider corrosion, temperature and the number of times the spring can be compressed before it breaks.

References

J.Shackelford, Introduction to Materials Science for Engineers, 3rd Edition, Simon and Schuster, (1995).

Comments on Sample Report 1

The essential facts were presented and were analyzed but the author made no attempt to convince the reader that the results are valid or even that the author understood the issues involved. Judging from the way that some ideas are presented (see the first paragraph in the introduction) one may wonder if the author was qualified to perform this experiment. Even if the results are correct the reader is not likely to accept these results at face value and consequently is not likely to put much stock in this person's work. Also, the author does seem to understand basic rules of capitalization and the use of first person voice directs the reader's attention to the author instead of the work. Finally, the conclusion does not address the results this work, but rather the authors experiences.

(Sample Report 2)

Measurement of the Spring Constant of a Helical Compression Spring

Author's Name
Course Number and Name
Institution and Campus
Date: (date submitted)

Abstract

A coil spring from the rear suspension of a Volvo automobile was tested in compression in order to measure its spring constant. This test was conducted using a 50 kN capacity testing machine, at a crosshead speed of 10 cm/min and to a maximum deflection of -xx%. Data was collected during both the loading and unloading phases of the experiment. The measured value of the spring constant was xx kN/cm. This was very close to the value (xx kN/cm) one calculates using standard spring design equations.

Introduction

Two major properties of any spring are its stiffness and safe load limit. A spring's stiffness is defined by the following equation

$$k = \frac{dF}{dx} \tag{1}$$

where $\boldsymbol{F}$ is the force applied to the spring and $\boldsymbol{x}$ is its resulting extension or contraction of the spring. For many springs the value of $\boldsymbol{k}$ is constant and therefore is generally called the spring constant. Even in these cases, however, there is a limit to how far one can stretch a spring or how much force it can sustain before it no longer returns to its original length when the force is removed. Such over-extension of a spring leaves it permanently deformed.

Both the design and materials used to make these springs determine the values of their spring constants and safe stress limits (or safe deflection limits). It would be very useful for an engineer to have a full appreciation for the design of these types of springs and the materials used in making them. In this investigation we tested a helical compression in order to measure its spring constant. The results were then compared to what one would expect using standard design equations.

Procedure

The spring we tested was a coil spring from the rear suspension of a 1968 Volvo sedan (model 142s). It was a left hand helical compression spring, had open ground ends, and was made of steel. The dimensions of the unloaded spring, the outside diameter, the total number of coils of turns and the wire diameter are listed in table 1. Using these dimensions the spring's fully compressed length (solid height) was estimated to be xx cm, or -xx% of its free length. This estimate was based on the following equation

$$\frac{\Delta x}{x} = \frac{N_T d - L_0}{L_0} \tag{2}$$

where N_T is the total number of coils, L_0 its free length and d is the diameter of the wire. This value was used to specify the maximum compression which was used in the test. Setting this value at xx% an estimate of the forces that would be generated was also made using the following equation [1]

$$F = \frac{G d^4 \Delta x}{8 N D} \tag{3}$$

where)x is the deflection of the spring, $N=L_0/N_T$ is the number of active coils, D is the mean coil diameter and G is the shear modulus for the spring material. Assuming the value for G is 80 GPa, which is typical for high-carbon spring steels (i.e., ASTM 229 [2]), the maximum force generated during the test should be xx kN.

Testing was conducted using an Instron model 4202 universal tester (serial number xx). It features a fully automated data acquisition and control system, a 50 kN load capacity, a movable upper crosshead and a maximum possible crosshead travel of xx cm.

At the start of the test the spring was placed on the lower platen and steel cables were attached to each end to guarantee the safety of laboratory personnel. Next, the crosshead was lowered until a preload of 10 N was applied, ensuring full contact between the spring and the platens. The position of the crosshead was noted and designated as the starting and ending points for the test. The crosshead was then moved down at a rate of 10 cm/min until -xx% compression of the spring was obtained. At this point the direction of travel of the crosshead was reversed. When it reached its original starting point the test was stopped.

Results

The results of this test are shown in figure 1. Note that the line is linear in both the loading and unloading stages of the test and that it retraces itself almost exactly. Also note that the line always starts and ends at the same point. This indicates that the spring was not permanently deformed during the experiment.

The average slope of the lines in figure 1 was determined using a least squares fit. For the loading stage the slope was xx kN/cm while the load at the origin was 10.031 kN. For the unloading stage the slope was xx kN/cm while the load at the origin was 10.001 kN. In both cases the coefficient of correlation was better than 0.999. One can see that the slopes are virtually identical. Therefore we take the slope to be the average of the two, xx kN/cm.

Since the slope of this line does not yield the spring constant for the spring alone, but for the spring and the testing machine, this slope had to be corrected to take into account the stiffness of the load testing machine. The stiffness of the testing machine was measured previously and found to be xx kN/cm. This correction is made using the following equation:

$$\frac{1}{k} = \frac{1}{m} - \frac{1}{K} \tag{4}$$

where m is the slope of the load-deflection curve and K is the stiffness of the testing machine. The correct value for the spring constant for the spring is xx kN/cm.

Discussion

The value of the spring constant which one would have expected to measure can be calculated using the following equation for the deflection of the spring [1]

$$\Delta x = \frac{8FND^3}{Gd^4} \quad \textbf{(5)}$$

which upon rearranging this equation yields the spring constant

$$k = \frac{F}{\Delta x} = \frac{Gd^4}{8ND^3}. \quad \textbf{(6)}$$

Using the same value for the shear modulus as before equation 6 yields a spring constant of xx kN/cm, which is within xx% of that which was measured.

At this point it might be useful to estimate the maximum shear stress experienced by the wire. Once again Machinery's Handbook gives us the formula for this:

$$\tau = \frac{FD}{0.393\,d^3} \quad \textbf{(7)}$$

which yields a value of xx MPa. This is considerably lower than the yield stress for typical high-carbon spring steels (i.e., ASTM A229, 0.55-0.85%C, oil tempered, tensile strength from 1140 to 1220 MPa, design strength is 45% of minimum tensile strength [2]) and so we were probably in no danger of over-loading the spring.

Conclusions

The spring constant was found to be xx kN/cm during both the loading and unloading of the spring. This value was close to the xx kN/cm one calculates using standard equations for the design of helical springs, giving one confidence in both the testing procedure and the process by which one designs a spring. In addition, the deflections used in this test and the forces generated were not sufficient to permanently deform the spring.

References

1. Machinery's Handbook, 23rd Edition, eds. E.Oberg, F.Jones, H.Holbrook and H.Ryffel, Industrial Press Company, New York, page 331, (1988).

2. Properties and Selection: Irons and Steels, Metals Handbook, 9th Edition, eds. , ASM, Metals Park, Ohio, volume 1, page 284, (1986).

Comments on Sample Report 2

This is a very good report. The reader would have to admit that the person who did this work did a very complete job and demonstrates a very good understanding of the subject. While a bit longer than the first report it uses the extra space to effectively convey the significance of this work, the author's awareness of the issues involved and precautions taken to ensure that the results were accurate. One's overall impression would have to be that the work appears to be solid and the report itself is a service to its readers. This type of report is more likely to be shared with a larger audience.