Compression Springs
Mechanical Engineering
Category A

New Mexico High School
Supercomputing Challenge
Final Report
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Team # 028
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Executive Summary

Our project is based on compression springs. Compression springs are used in many different ways, and have many different applications. We wanted to be able to design a spring for a user that would be optimum for their individual needs. Our program is designed to take some specific input values from the user such as parameters for the deflection and the diameter of the spring. Our program then calculates the exact values for these variables as well as other important specifications for designing a spring. To calculate these figures, we have written a program that tests specific values and their compatibility to other necessary equations in the design of a spring. Parameters are established in our program for error checking to ensure the physical capabilities of the spring and its realistic possibilities. This information is printed back to the user on the screen and saved in a file for further reference.

Our results will provide the user with a spring that is designed for a specific application based on their stipulations. Mechanical engineers who face the difficulties of developing their own springs for many different purposes could use this program. These engineers must use the equations that are in our program, but must do the calculations by hand or in several steps. Our program compiles the wide range of factors and variables that influence the development and performance of a compression spring.

Introduction

Purpose

The purpose of our project was to develop a program that would design a compression spring based on minimal input from the user to be effective for a specific application. There are plenteous factors that affect the performance and effectiveness of a spring. Our program is a compilation of equations(see Appendix B) that attempts to take these elements into account when creating the spring. Our project is designed to compile the needs of the user and determine the other variables that will make an efficient and stable spring.

Significance

Compression springs are used in many things throughout our life, and the specifications and development of these springs is a complex process that intrigued us. We developed the idea for this project after consulting with a mechanical engineer on possible project topics. The design of springs for specific purposes is a problem that engineers of all kinds are faced with in their numerous projects and creations. Our program will allow engineers or other scientists and users to develop a spring based on their needs and specifications, without having to do the multiple calculations by hand.

Compression springs have many specifications such as stress, deflection, load, the diameter of the spring, the diameter of the wire, the number of coils, and the free length. There are equations that combine certain factors. The stress of the spring depends on the load, the diameter of the spring, and the diameter of the wire. The deflection is dependent on the number of coils, the diameters, the load, and the torsional modulus of rigidity. The solid height and free length are factors that are determined based on the number of coils and the deflection. We researched the physics of compression springs and the mathematics behind them in several books, Internet sites and through communication with our mentors.

Project Description

To solve the complications of the various equations in this problem, we developed programming functions that solved each of the major equations. These functions take the inputted user values, and go through a series of loops to determine the value that coincides best with the other factors within the user's and the physical limits. The first function of our program finds the stress, the diameter of the wire, and

the exact vales for the diameter of the spring. The values for the diameter of the spring and stress are initially set at the lowest values determined by the user and the physical possibilities. These values are then put into the equation and the other dependent variables are found. These values are then checked for validity, and if the values are not appropriate, then the stress and diameter of spring values are incremented so that eventually all possible number combinations can be checked for their compatibility. Another of our functions uses a similar idea of starting at the low value, checking the realism of this value, and then incrementing the value and rechecking as needed. Our second function finds the number of coils and the exact value for the deflection. Our third function was developed to verify the stability of the spring. It uses many of the values such as the free length, the diameter of the spring, and the deflection to determine if the spring will buckle or if it is stable and secure. This function assures that our spring is physically possible, and stable.

Results

Our program will calculate the specifications for springs of all sizes, as we have input values of various ranges to determine the

physical reality of the output. Our program developed measurements for a spring to hold 5 pounds, with a diameter of .5 to 1 inch, and a deflection of 1 to 2 inches, as well as the measurements for a spring to hold 1000 pounds, with a diameter of 5 to 12 inches and a deflection of 4 to 6 inches. Our program displayed the information that it developed to the screen as well as saving it to a file for further reference. We successfully provided a program that will determine the values of the primary factors in designing a spring. We also used a computer aided drafting program to develop a visual graphic showing the values that our program is computing.

Conclusions

Our project developed a computer program to quickly calculate the values for the design of a spring, using both mathematical equations and user specifications. We determined the factors of the development of a compression spring, and their relationship to each other. Our program successfully used these equations to test calculated values, and to change these values if necessary and then test the new values until an appropriate set of corresponding values has been found. Our program also checks the stability of the spring and its buckling possibility. The

most significant achievement of our project was the ability to assemble the various equations and their implementations in conjunction with the user's inputted values and the physical capabilities of the spring to determine the values of the necessary variables.

Recommendations

We are continually trying to check the physical accuracy and engineering possibility of our programs results with springs of different dimensions and specifications. The idea of designing a spring is a very broad and unworkable field. To fulfill the requirements of our program in the time we were given, we had to limit the scope of our program to compression springs made from steel wire. This made our program more specific and better for its function, and is designed in a way that would allow us to determine other functions in our program that could expand its scope to other materials or even other types of springs at a later time. However, this limiting of our scope made our program workable and gave us the capability of completing our project and meeting our initial goals.

Reference List:

Associated Spring Corporation. *Handbook of Mechanical Spring Design*. Bristol, Conn.,U.S.A. 1951.

Wahl, A.M. Mechanical Springs.1st Edition. Penton Publishing Company. Cleveland Ohio. 1944.

Wright, Douglas. DANotes: Springs: Introduction. http://www.mech.uwa.edu.au/DANotes/springs/intro/intro.ht_ml. 1999-2001.

Appendix B

List of equations

Stress formula

$$S = \frac{8PD}{d^3\pi}$$

Where:

      P = Load on spring in pounds

      D = Mean diameter of coil in inches

      d = Diameter of wire in inches

      S = Torsional stress in lb. per sq. in.

Deflection and number of coils formula

$$F = \frac{8PD^3N}{Gd^4}$$

Where:

      F = Deflection in inches

      N = Number of active coils

      G = Torsional modulus of rigidity, which for steel averages

            11,500,000

Buckling

$$CD = 1 - \sqrt{1-(cD/\lambda L)^2} \ * \ (L/C)$$

Where:

CD = Critical deflection

c = constant 1.23 for steel

D = Diameter of spring

λ = method of support, = 1 when ends are free rotating, = 0.5 when

ends are guided and prevented from rotating.

L = free length of spring

C = constant = 2.62 for steel