Bench development for determination of characteristics of automotive suspendion springs

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Abstract: The paper presents the construction of a testing system for automotive suspension springs. The device is completely modeled using CAD system, making it possible to perform a numerical simulation of its operation. The mechanical device was developed using a conventional hydraulic press machine adapted for this purpose. The crucial element designed for this project was an amplifier and display system to present compressive load values of a load cell which is subject to spring compression force. Another key element in this study was the digital measurement system to determine the spring compression, using a digital caliper adapted for this purpose.

Keywords: Springs, suspension, automotive.

1. INTRODUCTION

The suspension system of a vehicle has the critical functions: to ensure the stability of the vehicle; comfort for vehicle occupants relative to the vibrations caused by irregularities of the track topography; proper handling; resist rolling chassis and react to longitudinal acceleration and braking and lateral forces generated in cornering [1].

Currently the use of damping with coil springs systems is widely used in the automotive industry, equipping city cars, offroad or sports. Regardless of material or manufacturing process, the spring damping system is subject to fatigue because of repetitive strain and eventually reduces its efficiency over time.

To enabling professionals in the automotive area to analyze in a simple and low cost the system of suspension springs sets, the goal is present the development of a suspension spring test tool which enables the technician to analyze the state of the vehicle suspension system by means of compression tests, acquiring load and deflection values and generating graphics in order to evaluate their behavior when calculating the elastic constant (k) and mean at each point.

2. METHODOLOGY AND DEVELOPMENT

The project was developed having the existing Spring testers in the Market as reference, based on the functionality and structure of the same. Tools were needed to implement and measure the loads applied to the springs to be tested and its consequent deflection.

To apply the test loads a hydraulic press was adopted from the Bovenau company to be stable and load capacity of 15000 kgf. It was made CAD modeling of the structure using the program SolidWorks.

To measure the applied load we opted for the use of a load cell, since the relationship between the strength and the output voltage is linear (nonlinearity 0.03%) simplifying the acquisition of data and ensuring greater accuracy. The chosen load cell is from Reacción company, model CZCB-500 [2] shown in Figure 2, with the capacity to 5000N and 2 mV / V.

Figure 2. Load cell model CZCB-500. Source: authors.

To measure digitally the spring deflection the options were to use a linear transducer or a digital caliper. We opted for the digital caliper, from Zaas company shown in Figure 3 by good precision (0.01mm resolution with accuracy of ± 0.02mm), good size for the project and especially for easy data acquisition because it allows communication serial, requiring only a connector for power and communication [3] which was made of acrylic.

Figure 3. Digital caliper from Zaas company with conector. Source: author.

With the structure assembled, starts the developing of a module for treating the received data of the machine and display it to the operator. Two printed circuit boards where made with the aid of software Proteus that receives signals from the digital caliper and the load cell, and sends it to a microcontroller that converts the load and deflection units for further analysis. Also a third display board for displaying the data has been used, all with the same base frame mounting board on board to accommodate them within a box.

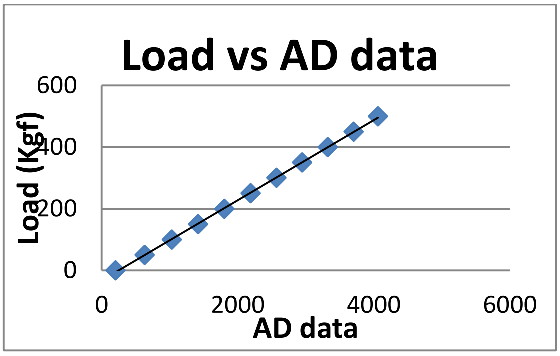
The next objective was to program the microcontroller to convert the signals into standard units of measures and structuring tests to obtain results which allow the analysis of tested springs. We used the software Arduino to program the features.

To decode the caliper data, the developed program checks the Clock signal analog input port time between pulses, if the interval is greater than 500µs one bit shift is performed to check the Data signal status and store in a variable. Dividing the value stored by 100 we get the measure, with 21º bit determining whether it is negative or positive.

For treatment of the load cell signal was necessary to develop a calibration method which consists applying ten known loads in two load cells simultaneously, one connected to the project board and another connected to a commercial module from Flexar company, for the purpose to check the value of the loads applied whith the second and save the read bits corresponding to each loading point to the first. After saving in variables the points acquired, a load/Reading graph (graph 1) was generated using the software Excel, the points were linearized and the straight line equation (1) was implemented on the program so that the reading acquired is the x of the equation. It was decided to allow access to the calibration only via serial communication.

$$y = 0{,}13x - 32{,}025 \qquad (1)$$

Graph 1. Load/AD data. Source: authors.



There are an option in the program to select the displaying units, these being kilogram-force (kgf), Newton (N) and pound-force (lbf) for load and millimeter (mm) and inches (in) to deflection. During the tests the measures are multiplied by constant relating to units selected for conversion purposes.

At this stage the project was ready for testing using suspension springs with the whole assembly mounted (Figure 15).

Figure 15. Finished prototype. Source: authors.

3. TESTS

The project was developed to perform tests on helical compression springs, which were characterized by aspects shown in Figure 16.

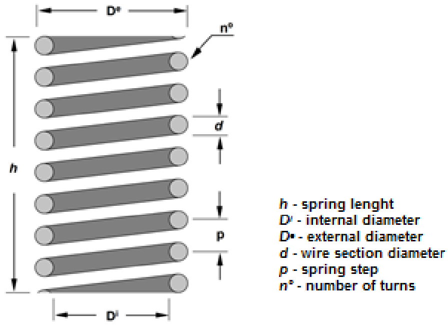


Figure 16. Characteristics of a helicoidal compression spring. Source: authors.

To perform the tests were used a set of front and rear springs of a Kadett GL 1995, provided by the technical course of automotive maintenance of the institution and a new front spring of a Vectra GLS 2.0/2.2, both of Cofap company.

With the Kadett springs set ran up the group test, two front springs and two rear with 40 mm and 80 mm points selected for the front and 30 mm and 70 mm for the rear. The loads required to compress 40 mm from the front springs were 86.1 kgf to the first and 90.4 kgf for the second, and to compress 80 mm where 160.7 kgf and 161.0 kgf respectively. To compress the rear springs 30 mm were necessary to first spring 102.2 kgf and 113.8 kgf for the second, and for 70 mm were necessary 240.1 kgf and 243.8 kgf respectively.

Using the equation of spring constant (2) we can obtain the value of k in the selected points of the springs [10].

$$F = k.\Delta l \qquad (2)$$

The first front spring presented 2164.6 kgf/m at 40 mm and 2013.9 kgf/m at 80 mm, the second presented 2270.5 kgf/m at 40 mm and 2017.5

kgf/m at 80 mm. To the rear springs was calculated 3664.8 kgf/m at 30 mm and 3438.4 kgf/m at 70 mm to the first and 3816.6 kgf/m at 30 mm and m 3491.3 kgf/m at 70 mm for the second.

As a result, it was observed that, in this case, wear has no parallel in both the front assembly and the rear, but showing near values of k between the pairs.

4. RESULTS

During the project development, the main focus was to integrate data acquisition devices in a single module and develop a product that provides the user with a set of useful data to the analysis of the tested springs. The three tests were designed considering the various situations and needs, since the use of a computer associated with the machine is not always possible.

It was found that the average time to perform each test by a trained person is 1 minute to single test and 10 minutes for the graph test, and even adding additional 3 minutes for the replacement of spring it remains advantageous compared to analog testing because the data acquisition is automated and the degree of accuracy independend of the operator.

4. FINAL CONSIDERATIONS

It was reached the main goal to develop a simple and reliable tool use in obtaining and displaying the data needed to evaluate the wear conditions of automotive springs of different sizes and strengths and can also be used to acquire the characteristics of new spring, because the supplier catalogs usually do not have such data.

Another factor contributing to satisfaction with the result was the low total cost of the project compared to other tools of electronic spring tests existing commercially [4], thus making the most handy tool for professionals in the automotive area.

As the project has experimental character is evident that a number of improvements can be made from the results obtained in this project, such as the optimization of program with the addition of more points acquired in the single test and group test, improvements in the press structure as linear guides to ensure greater stability in the spring compression and more suitable support to the caliper.

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