

# CHARACTERISTIC OF VEHICLE SUSPENSION COIL SPRING – COMPARISON OF EXPERIMENT AND FINITE ELEMENT METHOD SIMULATION

**Dawid Cuber**

*Wroclaw University of Technology  
Wybrzeże Wyspiańskiego 27, 50-370 Wroclaw, Poland  
tel.: +48 698 373 500  
e-mail: 188330@student.pwr.edu.pl*

**Mateusz Gandyk**

*Wroclaw University of Technology  
Department of Automotive Engineering  
Wybrzeże Wyspiańskiego 27, 50-370 Wroclaw, Poland  
tel.: +48 514 372 349  
e-mail: mateusz.gandyk@pwr.edu.pl*

## **Abstract**

*Coil springs do not always have regular geometry with constant pitch and constant mean diameter. Geometry of spring is more complex. Furthermore, spring stiffness could change with deflection. That makes calculation of spring stiffness more complicated than just putting four values into mathematical formula. In article has been presented two investigation methods of spring characteristic. Investigated object is a passenger vehicle suspension coil spring. Recognition spring characteristic is primary stage of vehicle dynamic suspension simulation. It has a very big impact on the vehicle height, comfort, handling and safety of vehicle. It is often assumed that vehicle spring has constant stiffness coefficient, which is sometimes a reason of incorrect suspension model. Vehicle springs rather have a progressive characteristic than linear. One of presented method is traditional, experimental compression test. Second, one is a measurement and modelling of spring geometry. Then analysing it in finite element method (FEM) simulation. Comparison has been done to check property of FEM process. Computed compression has been done in ABAQUS CAE 6.13-1 software. Analysis has shown that process of analysing is useful. There were obtained a good agreement between experimental research and computed model. In spite of irregular spring geometry, final characteristic is close to linear. Progressiveness is visible but not high.*

**Keywords:** *FEM, simulation, coil spring, vehicle suspension*

## **1. Introduction**

Suspension is important vehicle system. It is set of elastic elements coupled with links, which connects wheels or axles together with chassis.

Main task of suspension is damping and decreasing shocks and vibrations made by road irregularity on which vehicle move. It should protect passengers against unhealthy frequencies, gives comfort and help to maintain contact between tire and road. It is also important in vehicle parts reliability point of view. [1]

There are two main types of vehicle spring characteristic: linear and progressive. Characteristic of springs told how displacement versus force looks. When spring characteristic is linear natural frequency and consequently comfort depends on load (weight). When weight increases natural frequency decreases and comfort is higher. To make vehicle more universal producers use progressive springs. Linear suspension springs are rather used in motorsport.

Aside from material or production technology, the most difference between springs makes geometry. Geometry talks about that how high will be vehicle, how stiff and general about characteristic. Constructor must consider wire diameter, pitch and mean diameter as it is visible at formula of spring stiffness coefficient  $c$ :

$$c = \frac{G d^4}{8 i_c D^3}, \quad (1)$$

where:

$G$  – Kirchoff’s modulus,

$d$  – wire diameter,

$D$  – mean diameter,

$i_c$  – amount of working coils.

## 2. Spring characteristic obtained in experiment

To find real characteristic of spring was used Werkstoffprüfmaschinen-Leipzig GmbH ZD400 measuring machine (Fig. 1). Machine gives a load and shows deflection of investigated object – in this case coil spring.



Fig. 1. Measuring stand

Basing on measurements results it was possible to make a characteristic given in Fig. 2. Characteristic looks close to linear. Stiffness is about 22.8 N/mm.

## 3. Spring characteristic obtained in Finite Element Method software

Spring geometry measurements were done manually with callipers and spirit level bubble tool. The values were measured in the plane perpendicular to the plane of the first coil. Spring geometry (Fig. 3) was modelled in Autodesk Inventor software.

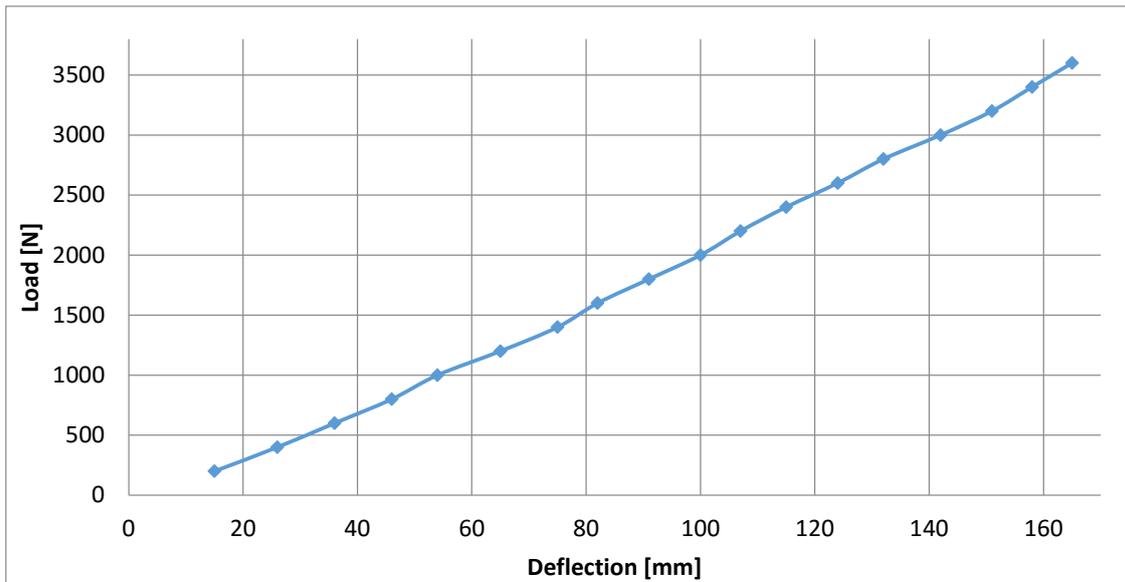


Fig. 2. Experiment spring characteristic



Fig. 3. Real (left) and modelled (right) spring geometry

Geometry in .igs format was imported to Abaqus CAE 6.13-1 software, in which was done FEM analysis.

Adopted elastic properties of spring steel wire ASTM A228 (Young modulus 207 000 MPa and  $\nu = 0.3$ ). Deflection was forced by force applied to the upper surface of the spring.

Figure 4 shows obtained in FEM software deflections. Lower surface has been fixed at Y axle. Degrees of freedom at X and Z axles was fixed in one point at the end corner of the coil.

Figure 5 shows stresses in cross section. They look typical to the torsion load which gives feedback that model has been done properly.

Figure 6 shows computed results characteristic. They are quite good related to the experiment results. Computed spring is little less stiff.

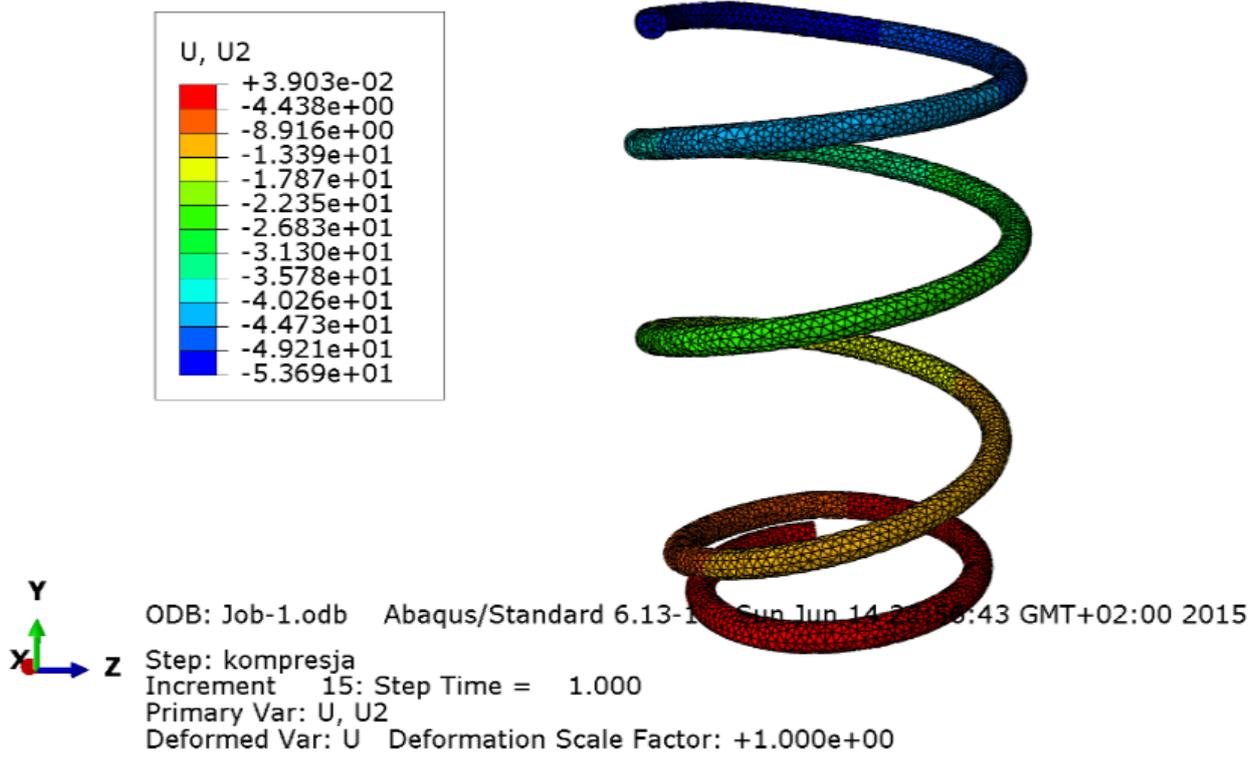


Fig. 4. Spring deflection under load = 1000 N

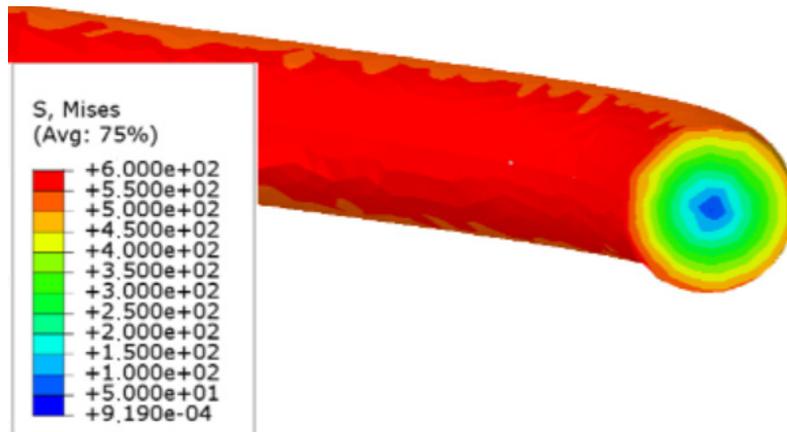


Fig. 5. Cross section stresses under 1400 N load

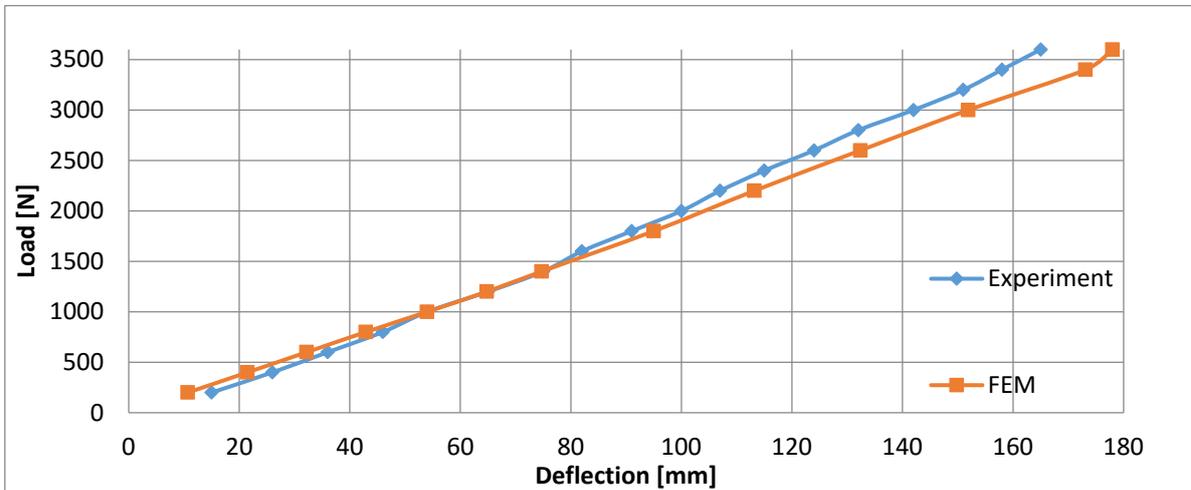


Fig. 6. FEM simulation spring characteristic with comparison to experiment

#### **4. Summary**

The aim of that comparison was to check if method is suitable to spring analysis process. In opinion of author is good enough and is useful in spring geometry designing process. Real and computed results are relatively similar. Not so big differences can result from differences of material properties, inaccuracy of measurements, differences in real and computed boundary conditions and measuring machine error. In further investigation, it would be good to check characteristic with higher load and make material expertise.

#### **References**

- [1] Orzełowski, S., *Budowa podwozi i nadwozi samochodowych*, WSiP, Warszawa 1999.
- [2] Siłka, W., *Teoria Ruchu Samochodu*, WNT, Warszawa 2002.

