INVESTIGATION OF THE INITIAL SYSTEM ANGLE OF A TORSION SPRING USING CAD

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RESUMEN ABSTRACT

Helical torsion springs with tangential legs are used for many applications: from simple, everyday systems like clothes pegs to advanced systems, such as sectional doors. Torsion springs are usually exploited with an inner rod as a guide. The space required between the spring and the rod make the spring tilt. Unfortunately, as far as we are aware, no industrial software is able to determine the initial system angle made by the spring in its tilted position. All the torque/angle curves are presented with relative angles. This means that, whatever the number of coils considered, the angle is null when the torque is null. For that reason, we have developed a methodology using both CATIA and ABAQUS to determine the system angle at the beginning of the behavior. The model exploits wires designed with CATIA and imported into ABAQUS for the center rod, the torsion spring, and the rods of the system to apply the torque. Several options for modeling contact between the various parts were investigated. They mostly used a connector with an axial property and a stop criterion. The results obtained are very interesting and enable further studies to be planned.

PALABRAS CLAVE: Torsion springs, CAD, accurate modeling, initial angle, CATIA, ABAQUS

1. CONTEXT OF THE STUDY

Mechanical compression springs are often used in mechanical devices for their ability to store and return energy. The range of their applications is very wide. When rotating parts are involved, helical torsion springs can be exploited to define the relation between torque and angle of rotation.

In the preliminary design phase, it is common to first define the geometries of the parts and then to find a suitable torsion spring that will give the expected torques for at least 2 system angles (the two bounds of the travel). An example modeled with Catia is shown in Figure 1. It shows the inner rod, which defines the rotating axle, and the two rods that will be in contact with the legs of the torsion spring. The system angle [A0B] is highlighted.

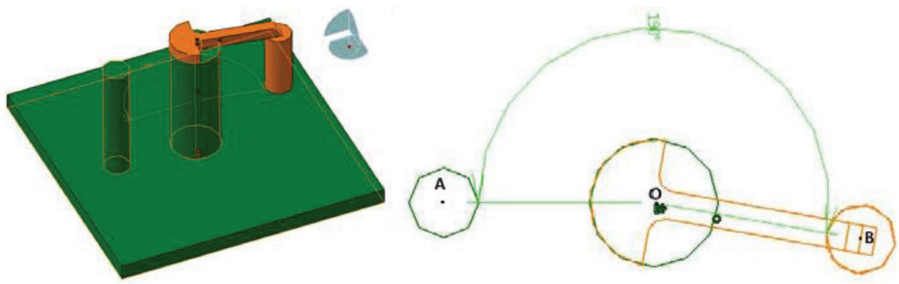

Figure 1. Example of rotating system

Once the system has been designed, the next step is to find a suitable spring for the application. Wahl's book on mechanical springs [1], which is considered as the bible of spring design, can be of help here. Designers can also refer to standards [2] or directly exploit industrial software dedicated to spring design [3-4]. Unfortunately, all the torque vs. angle relations are defined once the contact is established and none give an evaluation of the system angle. Designers can thus evaluate the rate of the spring but cannot evaluate when the spring will start to work in the system under study.

For a given system and a given torsion spring, it is of key interest for a designer to evaluate the initial system angle. Moreover, the space required between the spring and the inner rod mean that the spring will be tilted. Evaluating the system angle is thus a non-trivial issue. As a first step to satisfy this need, this paper presents a study that exploits both CATIA and Abaqus to evaluate the initial system angle.

2. USING CATIA AND ABAQUS TO EVALUATE THE SYSTEM ANGLE

To model the spring, 3D software, such as Catia, is usually exploited to obtain the geometry and then the 3D FEA in Catia itself or another dedicated software, such as, as Abaqus is employed. To go further, it is necessary to consider how torsion springs are manufactured. Helical torsion springs are usually manufactured with contact between the coils and no pretension. This results in the axial pitch being equal to the wire diameter and coils being tangential. This manufacturing issue makes it impossible to use the common process of 3D modeling and automatic meshing for FEA as all the coils of the spring will be merged at the tangential points. For that reason, Shimoseki et al. [5] proposed using wires to model the spring and the system. An example with a spring with tangential legs and 9.25 coils is shown in Figure 2.

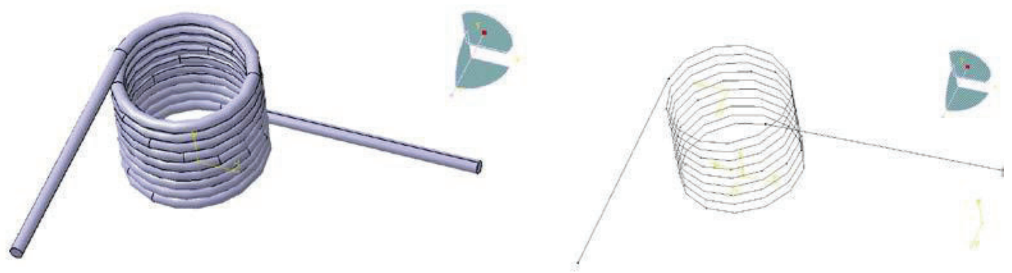

Figure 1. Example of a torsion spring with 3D and wire modeling

The wire associated with the torsion spring can be imported into FEA software. The next step is to simulate contact between the spring and the three rods - and many options are available. As an example, this paper presents a simulation that exploits 3 different ways to represent contact between cylinders modeled using wires.

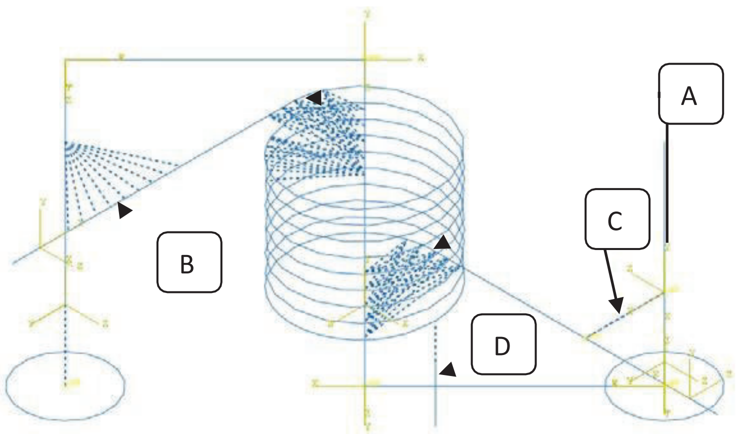

Figure 3. Modeling using Abaqus

Figure 3 highlights the model exploited with Abaqus. In Area A, the contact between the inner rod and the spring is modeled by axial connections between points. In area B, the contact between the spring and the rotating rod is modeled by a radial-thrust connection; and, in area C, 2 wire parts have been added and 3 cylindrical connections are used. Boundary conditions enable the rotating rod to move around the inner rod axis only and tie the other rods to the ground. Finally, a flexible beam has been added to link the spring to the ground in area D and avoid inconsistency.

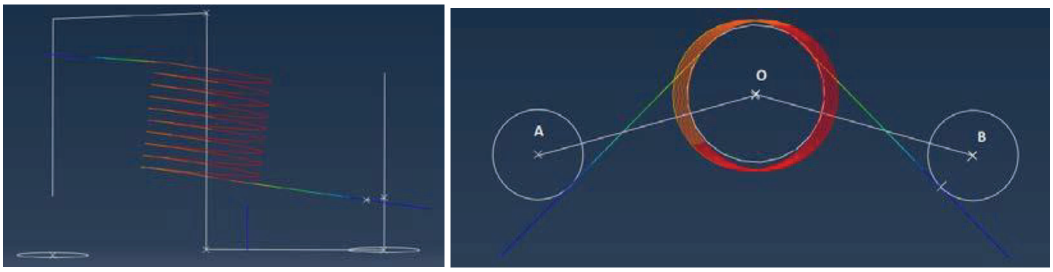

Figure 4. Results

The simulation (Figure 4 left) clearly shows that the spring is tilted when the contact is established. Moreover, the initial system angle [AOB] can be evaluated at 210° (Figure 4 right) and differs from the angle between the legs of the spring (270° for a spring with 9.25 coils).

3. CONCLUSIONS

We have shown that the accurate design of helical torsion spring requires an evaluation of the system angle when the spring first comes into contact with the rods. Simulation software can help to satisfy this need. This paper has shown that using wire modeling can be of great interest. We have pointed out that several modeling options can be exploited but the wire modeling leads to a fast solving process. Thus, further works may enable both the modeling and the solving process to be automated. Many experiments may be simulated in order to identify analytical laws that could be directly used by designers in preliminary designs.

4. REFERENCES

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