Figure 12.24 shows the contact pressure for the case of shrinkage plus shear force; but why does the legend show such high values? Because, let's not forget, we have used plane strain elements assigning them a thickness of 35 mm (see § 7.4.4) and the code, for this quantity, calculates the value for all the thickness and therefore to have the real datum it is necessary to divide the values of the scale by 35, as done in the figure for the maximum and the minimum. We observe that, being the minimum pressure greater than zero, it is confirmed the absence of detachment between pin and cage in the presence of the force S. Lastly, let us emphasize an important fact that we had highlighted in Chapter 7: when preloads are to be simulated (and press fit is a particular case of preload), the nonlinearity of the phenomenon would require that the load history be respected, which was done here, while it was not possible due to the intrinsic nature of the linear calculation performed in § 7.4.4; however, given the comparison of results in this specific situation, the linear approach appears equally valid. It must be said, however, that while for the gearmotor support the linear model might be more convenient in terms of modeling and calculation time, for the case of the cage the linear model required the creation of "GAP-type" elements in order to investigate the possible detachment of the pin from the cage, introducing a complication that does not exist in the nonlinear model with contact surfaces.

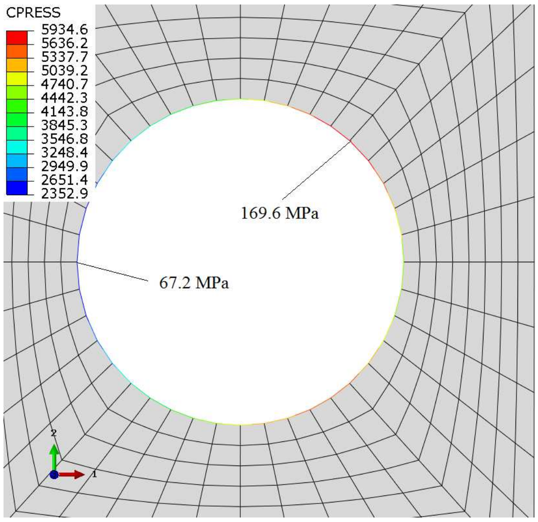

Figure 12.24. Contact pressure for shrinkage plus action S. The values in the legend should be divided by the thickness of the plane strain elements.

12.3.5 Self-contact

In some cases it may happen that a part comes into contact with itself, and if it is not possible to identify a master surface and a slave surface, it is necessary to define a "self-contact", that is a contact where the master and slave surfaces coincide; given the particularity of the case, the calculation code must treat this situation in a particular way. Without going into details, we show in figure 12.25 a coil spring: if we impose on one end a sufficiently high displacement while the other end is constrained, the spring will "pack", i.e. the coils will contact each other. Given the particularity with which coil springs deform under load (even if the load

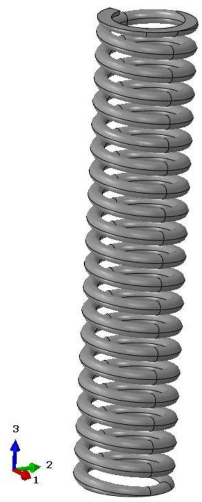

Figure 12.25. Coil spring.

is perfectly axial), it is not possible to establish a priori which will be the first point of contact. In a case like this, setting up a self-contact is the only way to solve the problem. Figure 12.26 shows the deformation of the spring when it has packed, while figure 12.27 contains the trend of the applied force as a function of the imposed displacement.

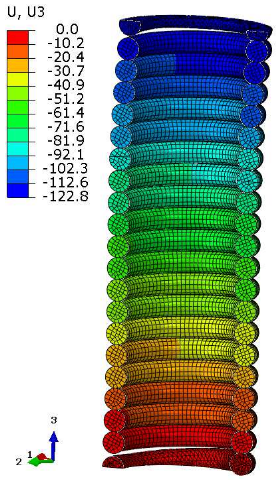

Figure 12.26. Spring deformed shape; cross section is highlighted.

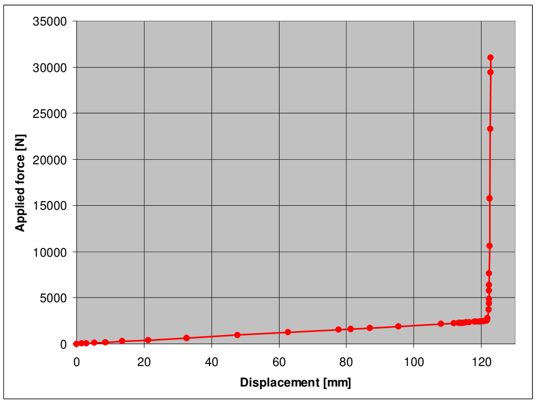

Figure 12.27. Trend of force as a function of displacement.

12.4 Some suggestions

Far from being able to exhaust such a vast subject that requires a certain amount of experience, in these few lines we will try to give some general advice on the problems of contact between bodies.

- Since each calculation code has its own way of dealing with nonlinear solutions in general and with contact problems in particular, it is a good idea to look at the documentation attached to the specific software in order to have a global view of the approach used.
- Before using contact elements with complex problems it is good practice to perform very simple tests to gain confidence on the behavior of the element (this would be a good rule to adopt whenever an element is being used for the first time, even in linear analysis).
- Before proceeding to the nonlinear calculation always carry out at least one linear solution: this allows firstly to evaluate the stiffnesses in the contact points, as mentioned above, and secondly gives way to evaluate the possible presence of problems or errors within the model in an easier way.
- Introduce the various improvements to the model one at a time. In this way it is easier to understand the origin of possible problems; for example if it is necessary to take into account the friction, start from a calculation in which