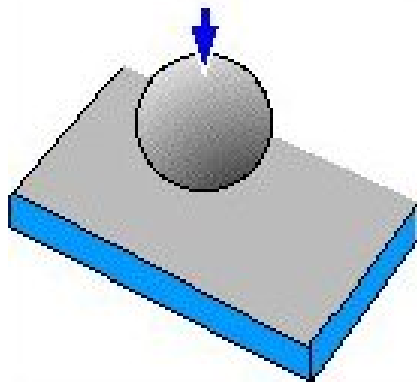


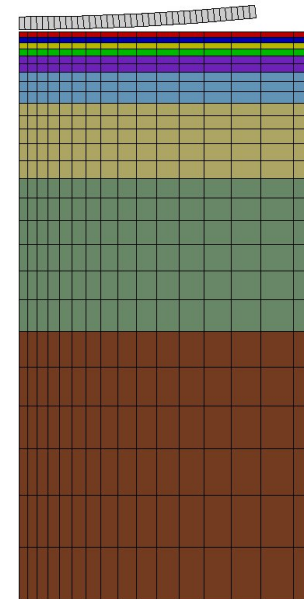
## Study of a sphere–plate contact - Influence of the thickness of the coating

In automotive as well as aeronautical industries, coatings are generally applied on the surface of bodies in contact in order to protect them from different mechanical or chemical effects such as oxidation, corrosion, extreme temperatures, wear, etc. The mechanical behaviour of this coating can be evaluated by using indentation tests on the coated surface. This is the subject of this mini-project. The aim of the study is then the definition of the suitable conditions to avoid the bias in the characterisation of the characteristics of the coating. The main question is: what is the minimal thickness that allows the user to reach the intrinsic properties of the layer ?

A rigid sphere and a coated half space are considered. The coating behaviour is elasto-plastic with a nonlinear kinematic hardening, the material of the substrate is linear elastic. We propose an analysis of the maximum and residual stresses in the half space (Fig.1) during the indentation test, and the characterisation of the global load–displacement curves.



*Fig.1: Illustration of the sphere–plate contact*



*Fig 2: Axisymmetrical FE mesh of a sphere–plate contact model*

Figure 2 shows the mesh available. Axisymmetric linear elements are used. A series of layers are predefined. They will be considered either as substrate or as coating for different analysis in order to build numerical models with different coating thicknesses.

*Keywords: Contact mechanics, coating, plasticity*

## Files available for FE computations

The files are given in a series of directories. The directory `0_substrate` corresponds to a contact between a sphere and a thick elastic cylinder: the properties of this cylinder will be kept later for the substrate. On the other side, the directory

## FE computations for different coating thicknesses

All the computations can be managed from the directory `Manage`. It contains:

- little shells that can be adapted according to users' wish to edit all the input files `calcul.inp` (VI), or all the `calcul.ut` files after the computations (VIu);
- a file to run all the computations (RUN);
- a file to run all the post-processings (RUNpp);
- three files to plot the results (DRAW to plot displacements from the `calcul.test` files; DRAWsig and DRAWeto to plot respectively the stresses and the total strain from the files `sig.txt` and `eto.txt` generated by the post-processing).

A series of guide lines are now given to the students.

1. Go to directory `Manage` and run all the computations by means of the command `RUN`.
2. Go to each directory (`0_substrate`, `i_layer` and `9_coating`) and run the command `Zmaster calcul` to check the computations. Draw the contour plots of the various stress components and of the total strain. Check the `calcul.test` files, to see what has been saved inside.
3. Go back to directory `Manage`. Check the file `DRAW` and adapt it to have relevant plots illustrating the differences between the various computations; run together the command `VI` and `VIu`: the aim is to adapt the output number in the postprocessing section, to draw the stress and strain profile at the proper time. Choose the relevant plots and draw the various figures by using `DRAWsig` and `DRAWeto`. Compute for each case the depth of the print remaining at zero load at the end of the test.
4. Plot the variation of the depth of the print  $h$  according to the thickness of the coating  $e$ .
5. This work can be made for various properties of the coating (change the constitutive equation in `coating.mat`).

Propose a synthesis of the computations according to two different points of view:

- what is the minimum thickness of the coating layer needed to get the true intrinsic properties of the coating by an indentation test ?
- what is the error made for a given thickness if one *forgets* that the layer thickness is too small.