

ABSTRACT

Modelling constitutes the cornerstone in the study of complex engineering problems. This valuable tool, is conscripted in this thesis to study the nanoindentation technique. In particular, modelling has contributed to the study of elastic and elastoplastic contact problems.

The results obtained from the simulations of elastic contact have been compared with the corresponding analytical solutions. From the comparison, it was revealed that these solutions fail to describe the exact contact problem due to the simplifying assumptions which govern them. By means of numerical methods and modelling, a correction factor was obtained, that improves Sneddon's analytical solution for the contact problem of a conical indenter with an infinite half-space.

Within the context of studying elastoplastic contact, the elastoplastic model was benchmarked with experiments and was found to converge. Furthermore, the ratio E/σ_y was examined with respect to how it affects the behaviour of the material during elastoplastic nanoindentation. Important results have emerged that concern the impact of this ratio on the profiles of the maximum and residual stresses and strains. In addition, the surface profile during the maximum loading and unloading, was investigated and it was ascertained to have a direct influence of the ratio E/σ_y on pile-up effects. Furthermore, it was observed that the reliability of the Oliver-Pharr method (which pertains to the analytical computation of the contact area) diminishes as the pile-up effects intensify.

The works of this thesis have been executed in the Nano-/Micro Mechanics of Materials Laboratory and the Research Unit for Nanostructured Materials Systems.

Keywords: nanoindentation, elasto-plastic modelling, finite element method, pile-up phenomenon