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Modeling constitutive and micro-scale frictional behavior of PTFE

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The work presented in this abstract is a part of a larger project called NANOPLAST whose aim is to produce injection moulding tool inserts with nano-structured functional surfaces. With such surfaces, features like antireflective-, hydrophobic- and color-effects will be possible to injection mould directly onto the surface of plastic parts. The nano-structures are transferred to the steel inserts by Nanoimprint Lithography (NIL). As the tool inserts are non-planar 3-D structures, so-called flexible stamps are used for the NIL manufacturing process. Unfortunately, the nano-structures can only be processed onto the flexible stamps in flat 2-D shape. Therefore, in order to create the nano-structures accurately on the curved tool inserts, prediction of the 3-D deformation of the flexible stamps is essential. These predictions are performed using finite element (FE) simulations. Flexible stamps are usually made of a polymer material and in this case polytetrafluoroethylen (PTFE), better known as Teflon, is used. The constitutive behavior of this polymer is prescribed through a 1-D rheological representation consisting of both non-linear visco-elastic and visco-plastic components. The contact between the flexible stamp and tool insert is modeled through standard Coulomb friction; however the contact conditions of PTFE against steel on micro-scale showed to be much more dependent on the actual contact pressure as compared to standard macro-scale observations. The constitutive model was verified through comparison with both experiments found in literature and by in-house performed uniaxial tensile tests. The combination of constitutive and frictional behavior was specifically verified through an experiment, where a PTFE sheet was deformed by a steel sphere mounted in a tensile test machine. Good agreement between simulations and experimental results was found, both regarding force-displacement and corresponding principal strain measurements. As expected, applying the correct frictional behavior between PTFE and steel on micro-scale is shown to be of major importance in order to accurately simulate the strain field in the deformed PTFE stamp.