Implementation of Dynamics Contributions into a Static Implicit Finite Element Program

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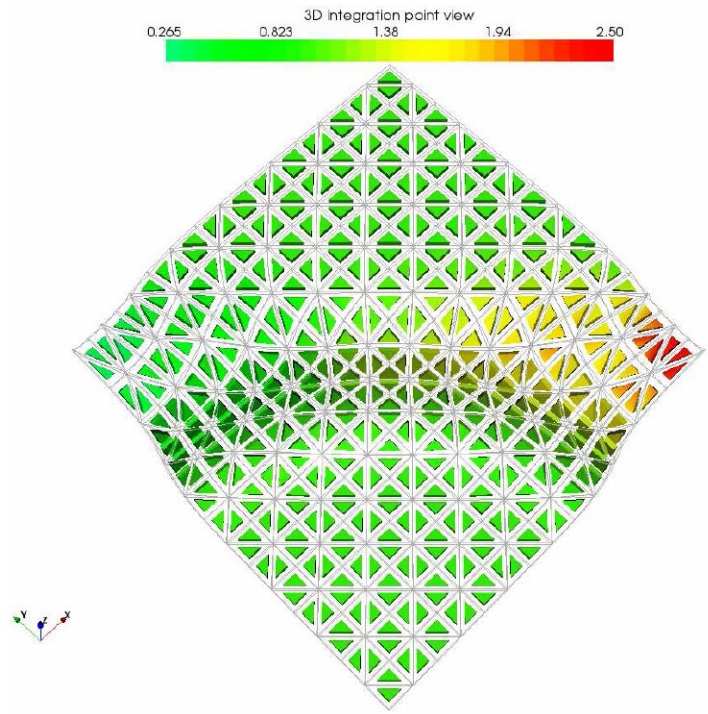

Deep drawing is a forming process that uses initially flat blanks of sheet metal to produce products ranging from simple ashtrays to complex auto parts. During this process a punch forces the blank into a die cavity. The final shape of the product depends on the tools and the process parameters that are used and on the material parameters. An extensive trail and error process is required to obtain a product that fulfills all specifications. However, by simulating the deep drawing process in a computer, this trail and error process can be completed more quickly and at reduced costs. Simulation of the deep drawing of a complex product can still take up to one day on a very powerful computer. By reducing the required computation time, while increasing the accuracy and improving the stability of the simulations, a faster time to market is possible. In a computer program that uses the static implicit procedure the inertia and damping forces are not taken into account. Integration of these forces, often referred to as dynamics contributions, into the static implicit procedure, results in the dynamic implicit procedure. This work is focussed on the integration of the dynamics contributions into a static implicit finite element program that is specialized in carrying out deep drawing simulations. Integration of the dynamics contributions requires the use of a time integration method in order to compute nodal velocities and accelerations. Both the Backward Method and the Newmark Method are implemented in the finite element program. Furthermore, a system mass matrix and a system damping matrix are implemented. The systemmass matrix can be either consistent or lumped. The systemdamping matrix is a linear combination of the system mass matrix and the system stiffness matrix. The implementation of the dynamics contributions was validated using small tests. The results of these tests showed good agreement with the known analytical solutions for both the Backward Method and the Newmark Method. The effects of the integration of the dynamics contributions on deep drawing simulations was also investigated. Simulations can be started with an unsupported finite element mesh when the dynamics contributions are taken into account. Furthermore, the dynamics contributions stabilize the contact algorithm. This results in a decrease in the number of Newton-Raphson iterations that is required. Using the Backward Method and mass scaling the number of Newton-Raphson iterations that is required, can be decreased by approximately 30 percent (compared to a simulation carried out without taking the dynamics contributions into account). Use of damping did not always reduce the number of Newton-Raphson iterations further. For use in deep drawing simulations, the Backward Method appears to be a more stable time integration method than the Newmark Method. Additional research is required to determine the influence of changes to the effective stiffness matrix on the convergence rate of the contact algorithm.