AN AUTOMATED ADAPTIVE PROCEDURE FOR 3D METAL FORMING SIMULATIONS

by

Jie Wan

An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the degree of

DOCTOR OF PHILOSOPHY

Major Subject: Mechanical Engineering

The original of the complete thesis is on file
In the Rensselaer Polytechnic Institute Library

Examining Committee:

Dr. Mark S. Shephard, Thesis Adviser

Dr. Robert L. Spilker, Member

Dr. Antoinette M. Maniatty, Member

Dr. Catalin R. Picu, Member

Dr. David P. Mika, Member

Rensselaer Polytechnic Institute
Troy, New York

January 2006
(For Graduation May 2006)

ABSTRACT

In 3D forming simulations the deformable parts undergo large plastic deformation that results in major changes in their geometry. The meshes of the deforming parts typically need to be frequently enriched to continue the analysis due to the large mesh associated errors including mesh discretization errors, geometric approximation errors and/or element distortions. To achieve satisfactory solution accuracy and computational efficiency, an automated simulation process based on simulation monitoring and adaptive mesh control executed through the application of local mesh modifications is developed. The adaptive mesh control procedure is coupled with FEM engines for automated finite element simulations of various types of 3D forming problems.

The decision for the need for adaptive mesh enrichment is made based on monitoring the errors associated with the mesh during the analysis steps. When the errors become too large, the analysis is stopped and an adaptive mesh control step is triggered to execute the needed localized mesh improvements and incremental solution transfer. The topological description of the part boundary is properly updated to reflect the current contact configuration and geometry features before the mesh enrichment process is applied. Error indicators based on plastic deformation related quantities are used to control the mesh discretization errors through an *h*-adaptive procedure. The mesh size field is further processed to effectively control the geometric approximation errors in the critical portions of the part boundary. To yield smoother and better local contact geometry, an approach based on the candidate contact prediction and subdivision surfaces is developed to construct improved geometric approximations on the part free boundary in areas where the mesh entities may become in contact with die surfaces within the next set of analysis steps. The mesh of the deformed part is modified through controlled application of local mesh modifications to meet both the needs of mesh discretization and element quality. The history dependent solution fields are incrementally and locally transferred from the old mesh to the updated mesh as mesh modifications are applied based on the developed local mesh modification driven solution transfer operators.

A set of industrially relevant problems is investigated to demonstrate the capabilities developed.