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HYBRID PCM/FEM FOR RIGID-PLASTIC ANALYSIS OF AXISYMMETRIC FORMING PROBLEM

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ABSTRACT

Meshless methods are a group of numerical method for solving partial differential equations on regular or irregular distribution of points. Meshless methods require no costly mesh generation and remeshing. In addition, meshless methods allow arbitrary placement of nodes, therefore the solution and its derivatives may be obtained directly where they are needed. Meshless methods are mostly based on weak form, in which background meshes are inevitable in implementation to obtain the numerical integration. Some meshless methods are truly meshless methods, in which no background meshes are introduced. In most meshless techniques, however, complicated non-polynomial interpolation functions are used which render the integration of the weak form rather difficult. Failure to perform the integration accurately results in loss of accuracy and possibly stability of solution scheme. The integration of complicated non-polynomial interpolation function costs much CPU time, too.

The point collocation method (PCM) has no issues of the integration scheme, the integration accuracy and the integration CPU time. Therefore, the point collocation method has some advantages such as no mesh, no integration. While, the robustness of the point collocation method is an issue especially when scattered and random points are used. To improve the robustness of the point collocation methods, some studies suggest that the positivity conditions can be important when using the point collocation methods. For boundary points, however, the positivity conditions cannot be satisfied, so that it is possible to get large numerical errors from the boundary points when using the point collocation methods. Specifically, the errors could arise in point collocation analyses with complicated boundary conditions.

Metal forming problems used to be analyzed by the conventional rigid-plastic finite element methods. But the conventional rigid-plastic finite element methods have some shortcomings as follows: 1) Mesh generation is needed, which is costly. 2) Remeshing is needed when deformation is appreciable, while remeshing results in loss of accuracy.

In this paper, for analyses of the rigid-plastic metal forming problems, a hybrid PCM/FEM is developed. By introducing a boundary layer of finite element in boundary domain of workpiece, unsatisfactory issue of the positivity conditions of boundary points can be avoided, and the complicated boundary conditions can be easily imposed with the boundary layer of finite element. An axisymmetric metal forming process is

analyzed by using the hybrid PCM/FEM.
A ring upsetting problem (see Figure 1) is analyzed, the nodal velocity field (see Figure 2), the contours of equivalent strain rate, equivalent strain (see Figure 3) and shear stress have been obtained successfully.

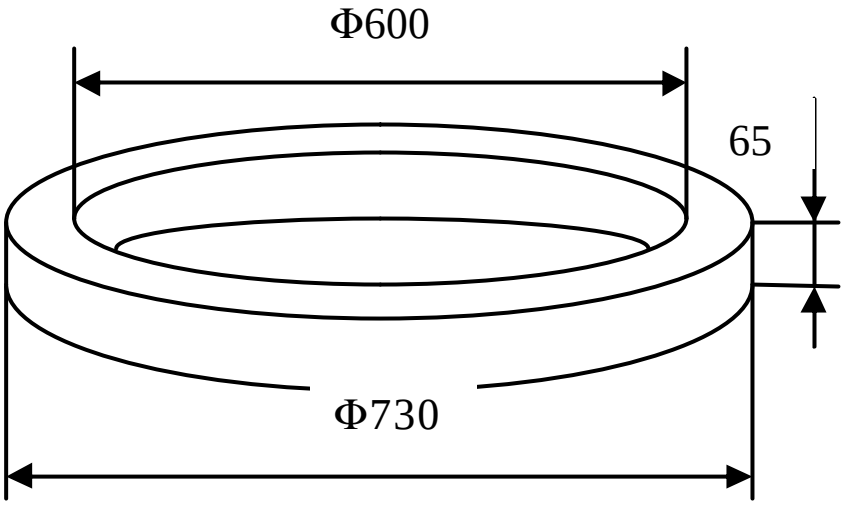

Figure 1: Initial shape and dimensions of the workpiece

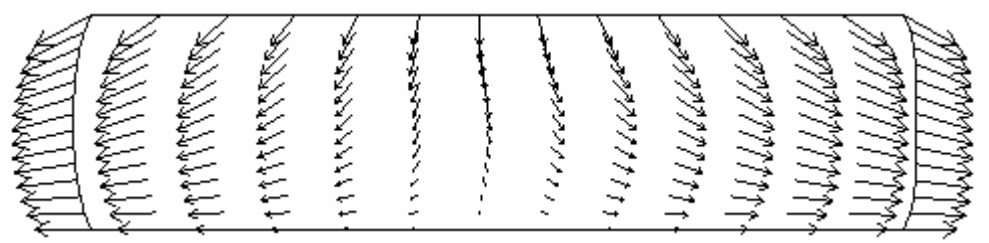

Figure 2: Nodal velocity field at 50% reduction

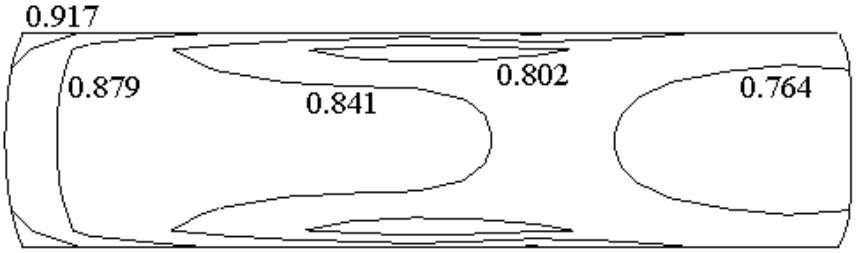

Figure 3: Contours of equivalent strain at 50% reduction

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