3次元one-step 有限要素法による自由鍛造解析

3D One-step Finite Element Analysis for Free Forging

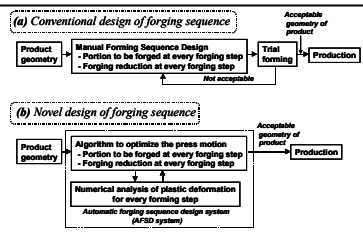
(Intelligent forging process for slab stretching)

東京大学生産技術研究所　柳本研究室

Chair for Hyper-functional Forming
Institute of Industrial Science, The University of Tokyo
Prof. Dr.-Eng. Jun Yanagimoto

RESEARCH OBJECTIVE

Three dimensional one- step finite element analysis is applied to estimate deformation in free forging. The obtained results by one-step approach are validated by comparing with experimental measurement.

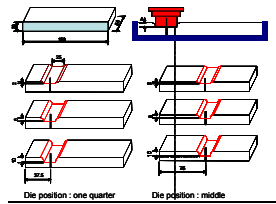


Schematic illustration of automatic forging sequence design system for free forging

Experimental procedure

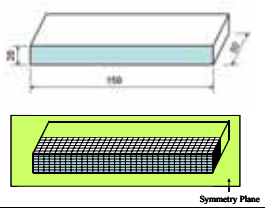
We made a fixture for clamping during the forming. Both sidebars, act as jaws to clamp and fix longitudinal elongation of the workpiece during forming. Base plate provides a flat surface as in the analysis. The thickness reduction values were 10%, 30%, and 50% of the initial thickness of the workpiece. We reduced the thickness at one-quarter and in the middle of the length of the workpiece.

1



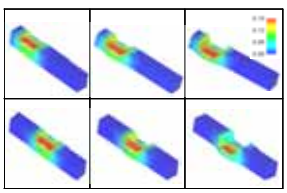
Considered geometry of workpieces before and after deformations for simulations and experiments

2



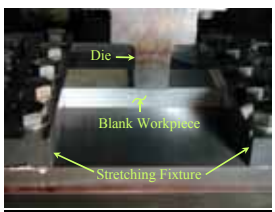
Descritized model for one-step FEM analysis

3



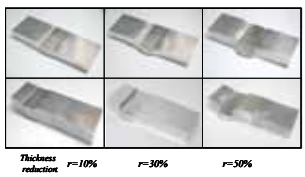
one-step FEM analysis: Grid distortions and equivalent srain distributions

4



Experiment set up : Blank workpiece clamped at both sides for stretch forming

5



Validation experiments: deformed workpieces

Simulation Procedure: COOPRESS system

The COOPPRESS system is a three-dimensional simulation code based on one-step rigid-plastic formulation. The schematic of the COOPRESS system and flow-chart of input/output data are shown in the following figure. Six forming cases were considered to evaluate the procedure of the COOPRESS system.

Results

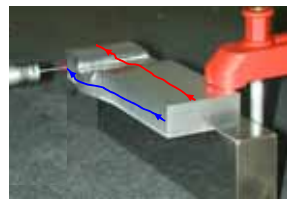
Deformation geometry, longitudinal thickness, and width spread distributions were evaluated by one-step finite element analysis within the COOPRESS system. In the case of middle position of die, volume loss during the one-step calculation for 10%, 30%, and 50% thickness reduction of slabs, were 0.11%, 1.03%, and 2.97% respectively. For the one-quarter position of die, volume losses in these cases were 0.12%, 1.04%, and 3.00% respectively.

Comparing the results of the experimental profiles of deformed workpieces and one-step finite element analysis, it was found that the one-step analysis is in satisfactory agreement with experimental ones. As a whole, dimensions are underestimated in the one-step analysis, because of the volume loss. That is clear that the amount of volume loss will increase by having large reductions. These amounts are really considerable if we should only discuss the accuracy of deformation, but it could be regarded relatively small from the view point of on-line modelling for IFS (Intelligent Forging System) as an on-line model does only require rough estimation for the geometry after forming. Furthermore, as the IFS forms a workpiece to an arbitrary geometry in an incremental manner, the reduction of the workpiece in compression will be relatively small. Then one-step FEM is promising as a basic model for automated design of the forming sequence.

Conclusions

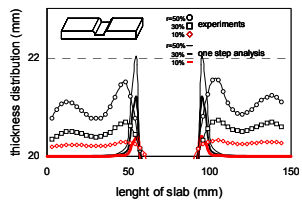
Three dimensional one step finite element analyses for free forging was established and applied to the simulation of six different cases. Experimental validation was carried out and the results were compared.

6



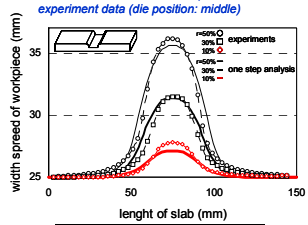
Measurement of width spread and thickness distribution of formed workpieces in the longitudinal direction

7



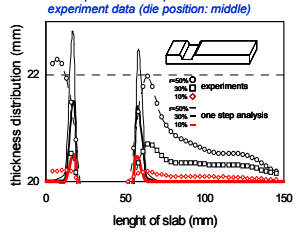
Thickness distribution: one-step simulation and experiment data (die position: middle)

8



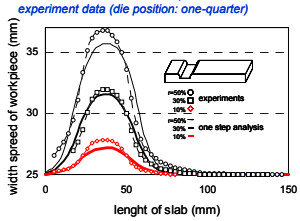
Width spread: one-step simulation and experiment data (die position: middle)

9



Thickness distribution: one-step simulation and experiment data (die position: one-quarter)

10



Width spread: one-step simulation and experiment data (die position: one-quarter)