AFDEX Newsletter 2017 Spring

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1. AFDEX_V17R01

1.1 Release date of AFDEX new version

AFDEX_V17R01 will be released on June 1. This latest version has greatly improved the functionality of the software by actively reflecting the users' needs. Key new features are briefly summarized in the table below, and the newsletter contains information about improvements, fixes and new features. New functions are to be supported by AFDEX Advanced module. The users of AFDEX Professional can use the beta version of the new module.

Type	Content
2D	-Simulation with die elastic deformation considered -Heat transfer analysis of assembled die -Structural analysis of assembled die -Recursive simulation between specific steps -Function for Boolean operation
3D	-Simulation with die elastic deformation considered -Heat transfer analysis of assembled die -Structural analysis of assembled die -Recursive simulation between specific steps

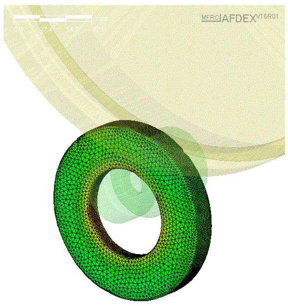
1.2 Update list of AFDEX_V17R01

Detailed update list is shown below.

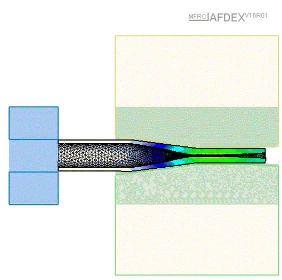
Type	Content
2D / 3D	New function for inputting a coefficient of friction and friction constant as a function of die pressure, temperature and strain of the contact material
	New function for considering heat transfer coefficient as a function of temperature and die pressure
	Lowering the default value of heat transfer coefficient (Based on users' feedback that heat transfer is slightly excessive)
	New method of updating temperature (To cover the theoretical limit when using small number of elements)
	In non-isothermal analysis, addition and improvement of the function for continuous analysis after changing stage
	In non-isothermal analysis, new function for die heat transfer analysis during transfer process
	In non-isothermal analysis, new function for continuing run during dwelling process
	Confirmed input data for predicting microstructural evolution
	New function to calculate the minimum distance between a node and the nearest die
	Improved last solution step
	New function for optimizing parameters together with HyperSTUDY
	Improved function for pushing the die penetrated nodes onto die surface when material penetrates die
	Improved algorithm for decreasing number of saved solution steps
	Increased number of data points from 500 to 1000 for load, volume change, number of nodes/elements, time increments, etc.
	Solved the problem of artificial change of temperature after piercing
	New function for moving compulsorily dies during simulation
	New function for specifying penalty constant for structural analysis of assembled die
2D	Improved treatment of 3 points on a line segment
	Enhanced function for simulating a process with spring-attached die
	New or improved function for calculating damage with or without circumferential principal stress considered
	Enhanced function for Boolean operation
	Increased number of dies for an assembled die from 7 to 19 in a single stage
3D	Mandatory input of boundary conditions
	Enhanced input system of boundary conditions for die structural analysis
	Improved function of die translation
	New function for generating a specially dense mesh for ring rolling
	Improvement of treating nodes contacting side wall of roll or tools during ring rolling simulation
	Improved scheme of separating nodes from roll or tools for ring rolling simulation
	New function to enhance the contact between die and workpiece
	In ring rolling process, new function for compulsory remeshing
	In ring rolling process, improvement and addition of a function for volume compensation scheme
	In ring rolling process, improvement and addition of functions for controlling center of material
	New function for interior ring rolling in which work-roll is located inside of the material
	Improved functions for positioning die and/or axial roll in ring rolling
	In ring rolling process, new function to check an error of input direction of rotation, i.e., angular velocity of the workroll
	New scheme to prevent workpiece from being swayed in ring rolling
	Improved function of heat transfer analysis for flow forming process
	Increased standard constants to actively cope with larger problems such as incremental forming processes
	Improved function for determining and adjusting a nodal state according to a depth of die penetration
	Improvement function of dealing with revolving die of which axis of rotation is fixed with the die or tool
	Fixed a bug regarding a speed jump at some singular points
	Improved treatment of boundary conditions at sharp corners
	Improved function of imposing boundary conditions and constraints on degrees of freedom
	In open-die forging and radial forging, improved function of pusher (manipulator)
	In open-die forging and radial forging, new function of setting a pusher (manipulator) at the positive x-end of the material
	New function of inputting variables to control pusher or manipulator in open-die forging
	New function of precise positioning of a periodically moving die

2. Newly embedded functions in AFDEX_V17R01

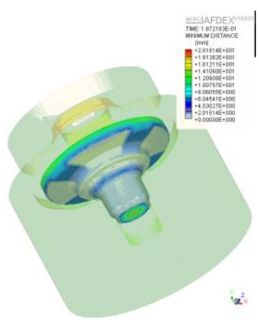
2.1 Fortified function for ring rolling process



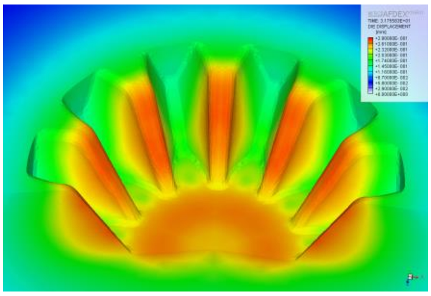
2.2 Enhanced function for open die forging process



2.3 Added function for calculating minimum distance between workpiece adjacent to die and die

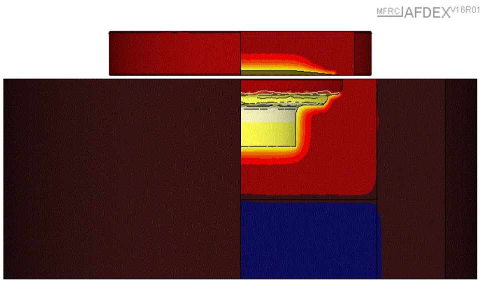


2.4 2D/3D simulation considering die elastic deformation



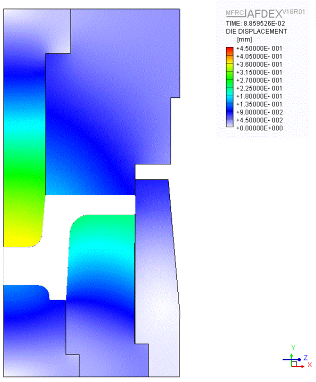
2.5 2D/3D heat transfer simulation between assembled dies

From the new version titled, “Advanced” of AFDEX_V17R01, it becomes possible to conduct heat transfer analysis between dies in a set of assembled dies. This figure shows 3D predictions obtained with heat transfer analysis between dies considered. Moreover, this heat transfer analysis can be conducted simultaneously with structural analysis between the assembled dies.



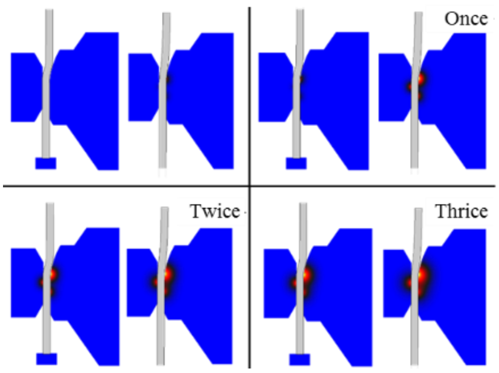
2.6 2D/3D structural analysis of assembled die

In AFDEX_V16, it was impossible to conduct structural analysis of assembled dies and metal forming simulation simultaneously. However, from AFDEX_V17R01, assembled die structural analysis can be accomplished with metal forming simulation at the same time. The image below is an example of the 2D/3D prediction when the two analyses are done simultaneously.



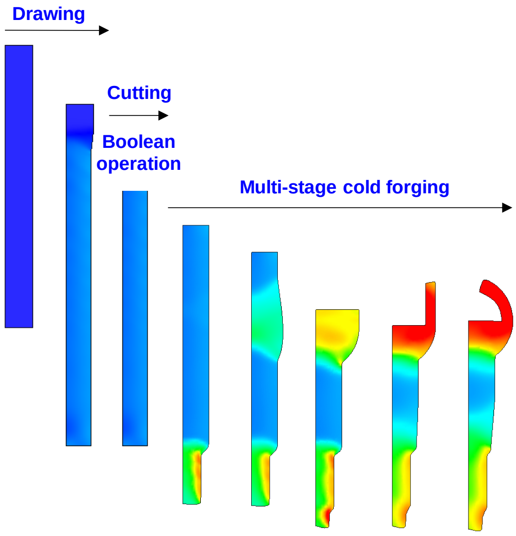
2.7 2D/3D recursive simulation for specific steps

Our latest update (AFDEX_V17R01) adds a function for recursive simulation for specific steps. This simulation is usually used for tracking the change in temperature of a die. After resetting a final die temperature of a previous process in the next process, the simulation will be proceeded repeatedly.



2.8 2D Boolean operation

A Boolean operation is added, which eliminates a specific part of workpiece while 2D simulation is running. By using this function, the material simulated by drawing or extrusion process can be continuously used for the consecutive forming stage.



3. 2017 Korean Society for Technology of Plasticity (KSTP) spring conference

The AFDEX development team will present the following papers at the Spring Conference of the Korean Society for Technology of Plasticity (KSTP). These papers cover the new features of AFDEX_V17R01 and related fields. It is thus recommended that AFDEX users participate in the conference to know the state-of-the-art of AFDEX.

2017 Korean Society for Technology of Plasticity spring conference	
1	Predictability of chevron crack by conventional ductile fracture theorem and its limitation
2	Causes of fracture occurring at the exit in a cold shell nosing process
3	Effect of air trapping occurring in hot forging
4	Engineering design of a cross-wedge rolling process of hot-forging preform of a ball-joint case
5	Analysis of springback and its verification in automatic multi-stage precision cold forging process of a yoke
6	Study on extreme cases of various numerical approaches to open cold extrusion
7	Practical approach to determining material parameters in microstructure evolution
8	Finite element prediction of deformation of material due to springback after material removal of forging
9	Finite element analysis of ring rolling processes using optimized tetrahedral finite element mesh system
10	Quantitative study on the effect of coupled analyses of die deformation and temperature on the predictions
11	Study on roundness of cylindrical hole formed by nonaxisymmetric cold forging

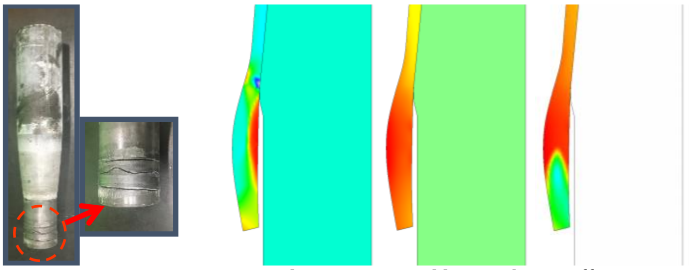
3.1 Predictability of chevron crack by conventional ductile fracture theorem and its limitation

Most researchers have used Cockcroft-Latham damage models. However, it exhibits significant difference in defect shape from experiments, as shown in Figures (a) and (b). Figure (c) shows the prediction of chevron crack occurring in an open multi-stage extrusion process obtained by a modified way. This study emphasizes the drawbacks of the Cockcroft-Latham damage model, which has a weak point in reflecting the effect of compressive deformation on the fracture.

(a) Prediction 1 (b) Experiment (c) Prediction 2

3.2 Causes of fracture occurring at the exit in a cold shell nosing process

It is general that the cracks occurring in cold forging are considered as a kind of ductile fracture. This paper deals with a brittle fracture occurring just after the fracture region passes through the exit in a cold shell nosing process undergoing more compressive plastic deformation. It is found that the maximum principal stress exceeds the strength of the material at the fracture point while its effective stress is less than the strength. The fracture occurred along the direction perpendicular to the maximum principal axis.

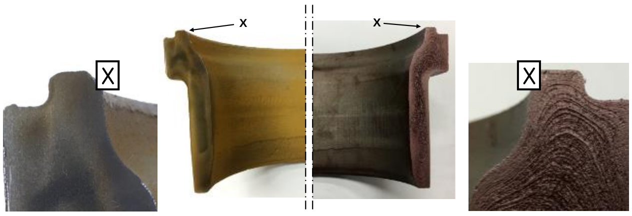


Principle stress Yield strength Effective stress

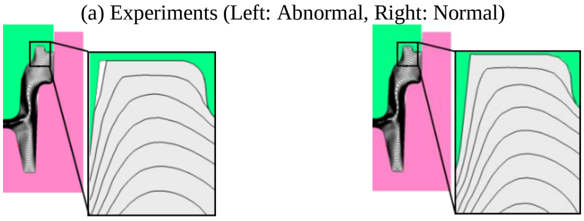
(a) Experiments (b) Predictions

3.3 Effect of air trapping occurring in hot forging

Air trap enclosed by the material-die interface where high pressure is exerted may cause an under-filling defect. This study predicts the under-filling defect due to air trapping phenomena. The internal pressure of an air trap is an empirical function of volumetric strain and it should not exceed the leakage pressure exerting on the material-die interface. The following figures compare the predictions with experiments, showing that they are in good agreement.



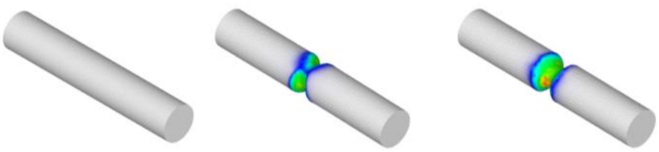
(a) Experiments (Left: Abnormal, Right: Normal)



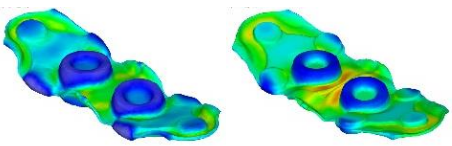
(b) Predictions (Left: Abnormal, Right: Normal)

3.4 Engineering design of a cross-wedge rolling process of hot-forging preform of a ball-joint case

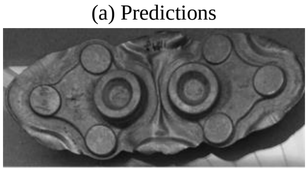
In this study, a practical and economical preform for a ball-joint case hot forging process is proposed, which is fabricated by a cross-wedge rolling process just before being hot forged. The new preform may contribute to reduction in maximum die stress by approximately 40%. The following figures compare predictions with experiments.



Initial Mid Final



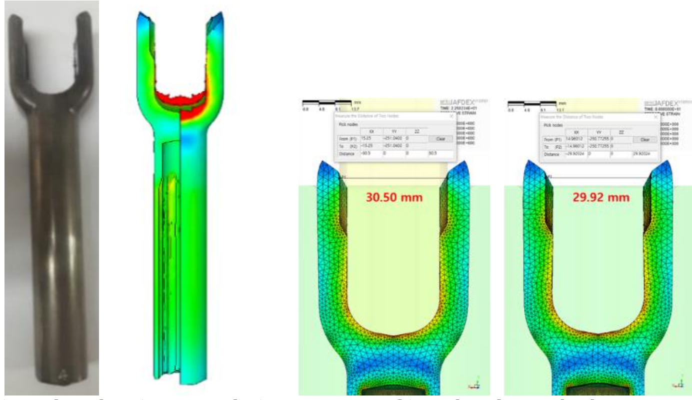
(a) Predictions



(b) Experiment

3.5 Analysis of springback and its verification with an automatic multi-stage precision cold forging process of a yoke

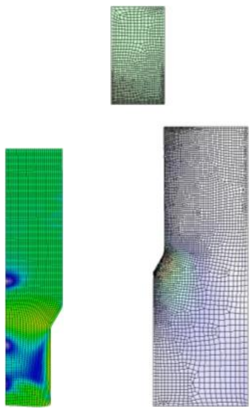
This study predicts the change in distance between two ears of a yoke due to springback during unloading process after being forged by automatic multi-stage precision forging. The change in the distance was predicted as 0.50mm and that of the experiment was 0.58mm, which indicates that they are quantitatively in a good agreement.

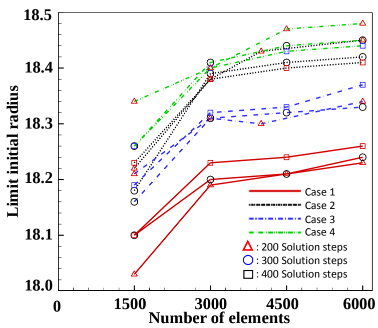


(a) Final product (Exp..: Predict) (b) Predicted springback

3.6 Study on extreme cases of various numerical approaches to open cold extrusion

These figures below show an open extrusion process. The maximum allowable reduction of area is very important especially for automatic multi-stage precision cold forging of long shafts. The geometry of open extrusion appears simple, but its numerical analysis is not that simple. The most important factor of the process is the reduction of area which is defined by the uppermost and lowest contacting points of material with die, implying that it changes at every solution step. This study deals with numerical characteristics of material and die models to give some insight on the theoretical models to application engineers or researchers. It was found out that the predicted maximum reduction of area is non-negligible and much dependent on the material and die models.

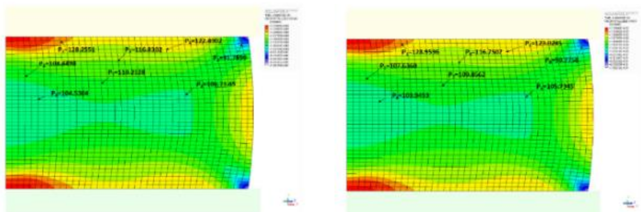




(a) Effective strain (b) Limit initial radius of material

3.7 Practical approach for determining material parameters in microstructure evolution

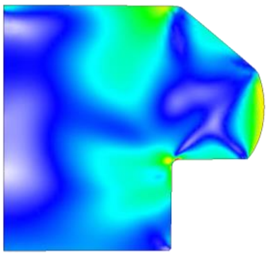
Figure (a) shows predictions of grain size with known material properties and Figure (b) shows predictions of grain size with material properties calculated by a new material identification scheme, which is based on AFDEX and HyperSTUDY. The new scheme needs experimental data as input to identify the material. In this study, the experimental input was replaced by the predictions obtained using the known material properties. As can be seen in these two figures, they are very close to each other, implying the scheme of material identification for predicting microstructural evolution is powerful and economical.

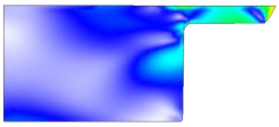


(a) With known material data (b) With identified material data

3.8 Finite element prediction of deformation of material due to springback after material removal of a forging

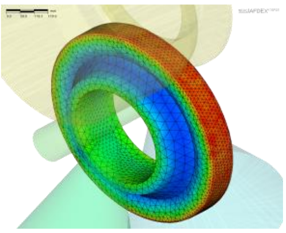
Figure (a) is a quadrilateral mesh used for predicting the residual stress by the elastoplastic finite element method. Figure (b) is the mesh used to perform the springback analysis after machining the upper part with the lower part fixed. The changes of the corner angle were recorded as 0.18° and 0.14° from experiments and predictions, respectively. Thus, the results from experiments and predictions are approximated with reasonable accuracy.

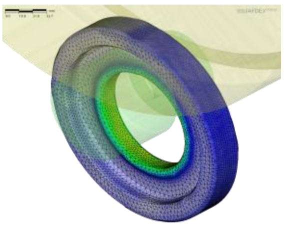

(a) Residual stress after forging


(b) Residual stress after machining

3.9 Finite element analysis of ring rolling processes using optimized tetrahedral finite element

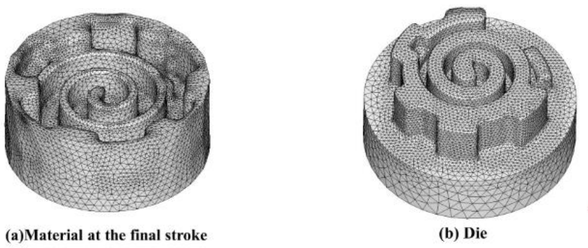
Ring rolling is representative incremental metal forming process which needs much computational time for simulation. Of course, it needs enhancement of solution accuracy. Mesh system cannot be overemphasized for both the computational time and the solution accuracy. This study suggests an optimized mesh system specialized at ring rolling, which meets the requirement of good contact between material and tools as well as minimization of number of remeshing. The following figures show the usefulness of the capability, i.e. mesh systems with torus-type densified mesh automatically generated considering the contact interface.


(a) L-type cross section of large ring rolling

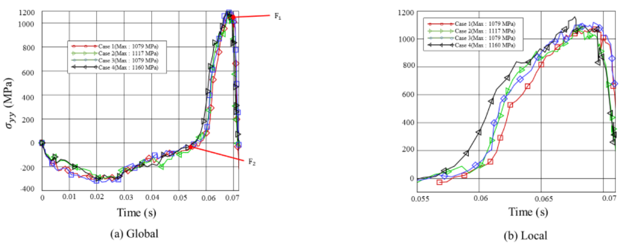

(b) Stair cross section of small ring rolling

3.10 Quantitative study on effect of coupled analyses of die deformation and temperature on the predictions

Scroll forging is considerably affected by temperature of material and die deformation during forming, implying that it is appropriate to use it for investigating the effect of material and die models on the process. Four combinations arising out of two material models, i.e., rigid-viscoplastic and rigid-thermoviscoplastic and two die models, i.e., rigid and elastic are studied to reveal the reasons of die fracture occurring in a fixed scroll forging process. The predictions are compared in detail to quantitatively differentiate each simulation case from the other. The discussion can give some insight on material and die models to metal forming engineers and researchers.



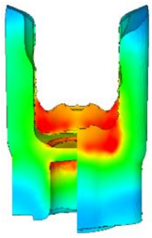
(a) Finite element analysis model



(b) Predicted curve of die tensile stress based on analysis model

3.11 Study on roundness of cylindrical hole formed by nonaxisymmetric cold forging

This study is to reveal causes of ellipse-like cross-section of inner surface of hollow part formed in pinch-yoke by backward extrusion process. It was disclosed that the fundamental reasons of the defect lie in plastic flow of the material and that it can be improved by optimizing the gap between the material and the die. Elastoplastic finite element method was employed and effect of springback on the elliptical profile is, however, negligible. A comparison of ellipticity between prediction (1.03) and experiment (1.038) was carried out, showing that the predictions are quantitatively acceptable.


(a) Prediction (Effective strain)


(b) Experiment

4. Public notice

4.1 MFCAE 2017

MFCAE 2017 will be held in Changwon, Korea on August 17 and 18, 2017. With this AFDEX user conference, participants have a chance to share new features and use cases of AFDEX. We welcome you and look forward to your active participation. The location and date could be changed and it will be announced to users through homepage and e-mail when the date and location is changed.

	Location	Date	City	Topic
1	Pullman ambassador	August 17~18	Changwon	Case study

4.2 Global exhibitions

4.2.1 EATC 2017

2017 European
Altair Technology Conference

June 26-28, 2017
Frankenthal, Germany

Altair's European Technology Conference will be held in Germany from June 26 to 28 for three days. This is Europe's leading PLM technology exhibition, attended by experts from diverse fields, including aerospace, automotive, electronics and heavy equipment. The AFDEX development team will interact with visitors on the latest cutting-edge industrial technology trends and promote the excellence of simulation technology through the AFDEX new version.

4.2.2 MF-Tokyo 2017

MF-Tokyo 2017

July 12-15, 2017
Tokyo, Japan
Hall 005, Booth 57

MF-Tokyo 2017 will be held at Tokyo Big Sight Exhibition Center for four days from July 12 to 15. MF-Tokyo is a specialized exhibition of machinery industry technology. It is composed of various fields such as forging, automation, surface iron and welding. This big exhibition consists of about 30,000 visitors and 1,300 exhibition booths. The MFRC will set up an exchange platform for the machinery industry at Hall 5 and 57.