AFDEX Newsletter Q3 / 2023
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Contents

1. AFDEX_V23R02 Release

AFDEX_V23R01 was released in South Korea in this May, and the newly updated version, AFDEX_V23R02 is planned to be released in the end of July 2023.

The improvements in solver and pre/post-processors AFDEX_V23R01 are described in Section 2 and 3.

2. New Features in AFDEX_V23R02

2.1 Shape Rolling Process Controls in Pre-processor

Previously, the basic input setting of the analysis condition is completed through the pre-processor of AFDEX, while the other inputs for specific conditions of the shape rolling process simulation such as the boundary conditions of rolls and materials were done by text file. For the convenience of use, AFDEX_V23R02 provides that all input data can be written in the pre-processor.

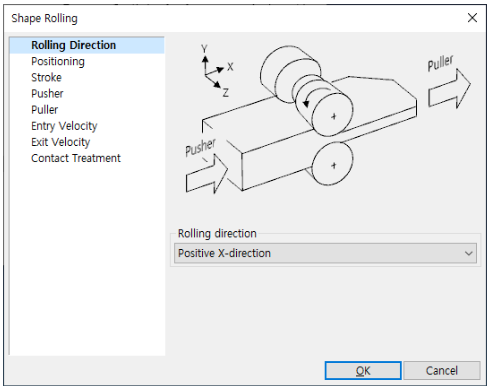


Figure 2.1 UI for shape rolling process option

2.2 Cone Type Roll Piercing Simulation

Barrel type roll piercing process simulation has been supported by older versions of AFDEX (M. S. Joun et al., 2014, Quantitative study on Mannesmann effect in roll piercing of hollow shaft, Procedia Engineering, Vol.81, pp.197-202). AFDEX_V23R02 provides not only the simulation of barrel type roll piercing process, but also cone type roll piercing process simulation which is used for manufacturing seamless pipes. Figure 2.2 shows a typical analysis results of cone-type roll piercing process.

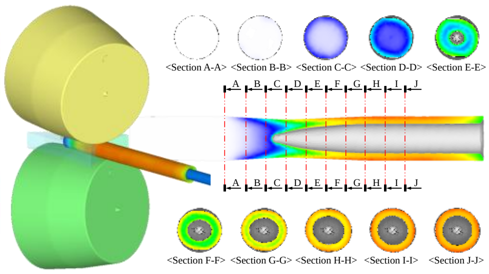
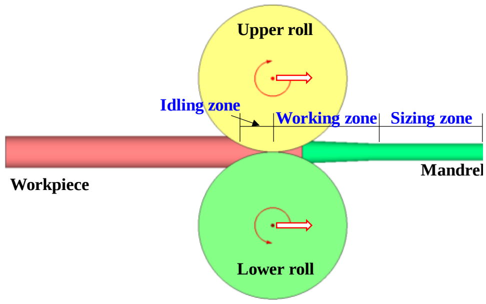


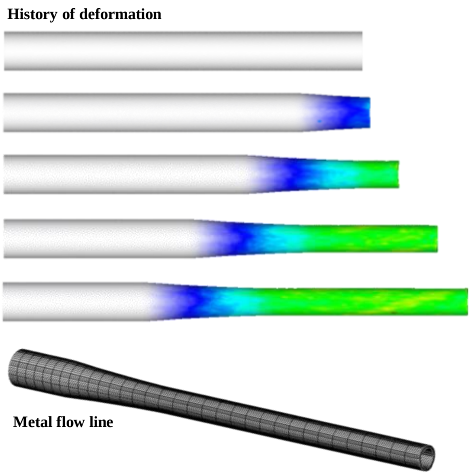
Figure 2.2 Analysis result of cone type roll piercing process

2.3 Automatic Simulation of Pilgering Process

Pilger rolling process is one of incremental forming processes and also a special metal forming process that combines the technology of rolling, extrusion, upsetting, and etc.. Pilgering process enables to mass-produce pipes with automation and eco-friendly high yield.



(a) Process definition



(b) Deformation, effective strain and metal flow line
Figure 2.3 Simulation of pilger rolling process

Recently, AFDEX provides the fully automatic simulation of the pilgering processes covering both single and composite materials. The fully automatic simulation is available using either rigid-plastic FEM or implicit elastoplastic FEM by entering the inputs involving feed rate, rotation angle, etc. A special mesh system with layers in the thickness direction is available.

Figure 2.3 shows the analysis results of the example from a reference. The simulation was fully-automatically conducted.

2.4 Simulation Results Compression

During the simulation, the result file may become larger in size if the number of elements or steps stored is large. In order to solve this issue, AFDEX_V23R02 provides the selective save feature which lets users save the result data of desired solution steps. Various options to select the solution steps to be newly saved are prepared. Figure 2.4 shows the UI for the selective save feature.

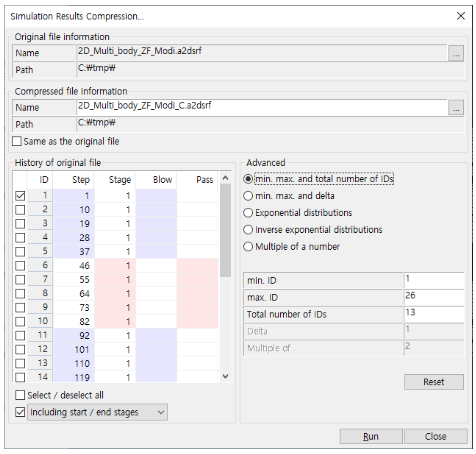


Figure 2.4 UI for supporting selection of desired solution steps to be newly saved

2.5 Scaling a Workpiece Model after Forming

Since hot forging product is formed with a heated material, thermal expansion is an important consideration for the process design. The material in the state where the current analysis has been completed is one that has been subjected to thermal expansion. In the previous version, it was not possible to check the shrinkage dimensional information of the material due to cooling after forming in the post-processor. AFDEX_V23R02 provides the checking feature for the size of the material that has been shrunk using the scale adjustment function through the post-processor. Figure 2.5 shows the scale tool in pre-processor.

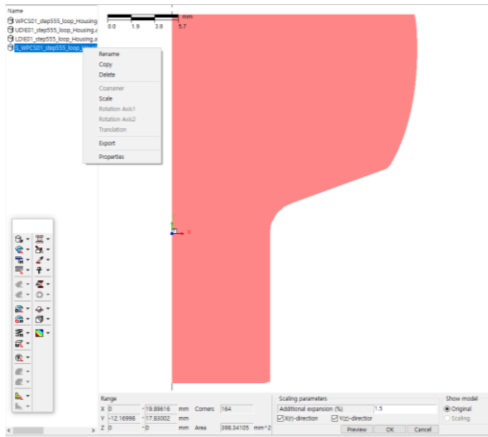


Figure 2.5 Scaling model in pre-processor

2.6 UI for Inputting Translation Distance of Dies in Multi-stage Process Analysis

Multi-stage process analysis starts automatically after initializing the position of dies. In the previous version, relative position between dies inputted cannot be modified during the initialization step if two or more dies for each upper and lower dies are used for a simulation. Since this, it requires to determine accurately the relative position of dies in advance for the automatic continuous process simulation.

For most problems, this procedure is simple, while for special processes, the relative position itself is a process design factor that must be considered during process design.

In AFDEX_V23R02, the feature of changing the relative position of a die during the automatic simulation is added. For the selected die, the displacement of the rigid body movement is entered before the start of the forging stage. (Figure 2.6)

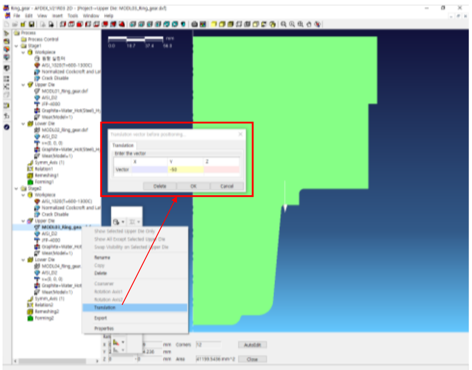


Figure 2.6 Inputs for translation distance of dies

2.7 Selective Remeshing Feature in Multi-body Analysis

Previously, remeshing had been applied to whole objects or materials during finite element analyses of multibody structures or metal forming processes. Now, AFDEX_V23R02 provides the feature of automatic mesh density control which can find a core of a die. AFDEX_V23R02 enables users to set remeshing feature for each object. This feature can reduce the calculation time and improve the accuracy of the solution by selectively remeshing parts in the multi-body analysis.

However, if it is necessary to use the remeshing due to the extreme distortion (Negative Jacobian) on finite elements during calculation, the remeshing is performed for the entire model.

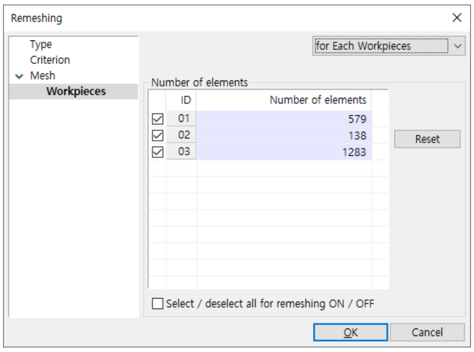


Figure 2.7 Selective remeshing option dialog box

2.8 Support for Multilingual Characters

AFDEX_V23R02 supports multilingual data and data-saving system for names of analysis input and result files, and words, phrases, and sentences in the analysis input file. Therefore, miscellaneous files are read and saved in UTF-8 format.

Also, the new version of AFDEX supports all the multilingual characters for all types of file paths, file name, and DB files. Figure 2.8 shows Japanese support on AFDEX_V23R02.

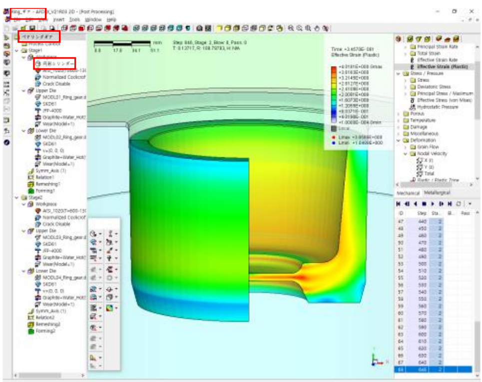
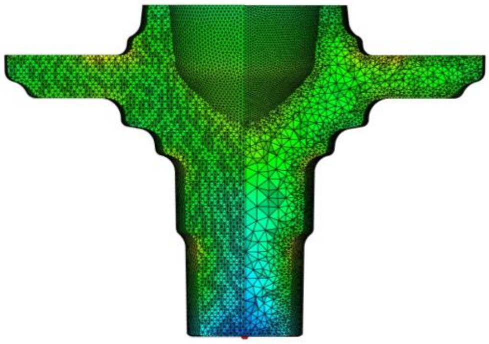


Figure 2.8 Support for multilingual characters

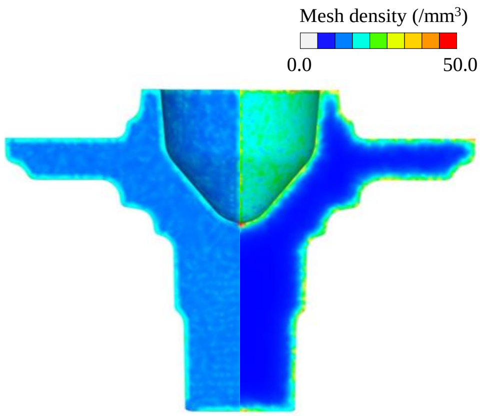
2.9 Effect of Mesh Density Visualization Feature and Density Distribution on Analysis Results

In AFDEX_SP_V23R02, 3D internal element visualization feature (Figure 2.9) and element density distribution visualization feature (Figure 2.10) are officially provided.

Figure 2.9 shows that the two meshes do not generate large errors in terms of the deformation shape of the material. Therefore, non-uniform meshes (Figure 2.9 (b)) has been recommended for the case of simulation focusing on forging possibilities in terms of computational efficiency. From an empirical point of view, however, a severe non-uniform mesh may have a negative effect on the accuracy of a result if the target is stress distribution of dies with a large local deformation. For a detailed information on this, please refer to our academic references.



(a) Uniform mesh (b) Non-uniform (Internal coarse)
Figure 2.9 Visualization of internal mesh



(a) Uniform mesh (b) Non-uniform (Internal coarse)
Figure 2.10 Distribution of mesh density

3. AFDEX_V23R02 Improvements

3.1 Post-processor for Multi-body Cases of Materials and Dies

AFDEX_V23R02 includes the plot with a legend for the number of nodes and elements for each die used for multi-body analysis. AFDEX_V21 and earlier versions had not provided this feature.

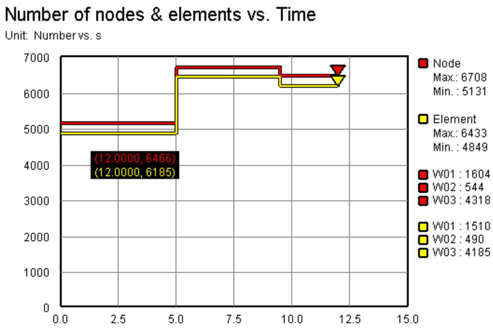


Figure 3.1 Improved UI for node/element information in multi-body analysis case

3.2 UI for Inputting Number of Elements for Remeshing in Die Structural Analysis

The mesh generation of dies is required for a die structural analysis, and high-density fine mesh can be used on a specific portion of dies. Generally, automatic mesh density control technique is applied on the die surface which is in contact with a workpiece, but user intervention can be necessary in case of special processes. Previously, input box for the number of elements of dies was included in the modeling dialog box, which was confusing for users to find it.

AFDEX_V23R02 allows users to input data of a material or a value of the number of elements for each die in the remeshing dialog box.

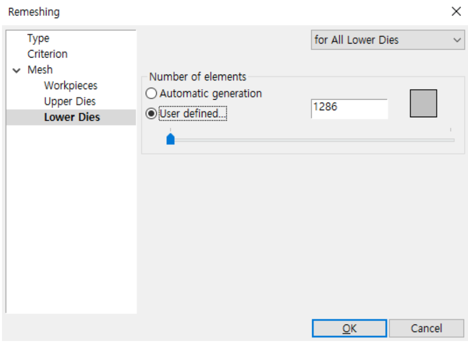


Figure 3.2 Dialog box for controlling number of elements

3.3 Pre-processor Improvement for Crack Analysis

Recently, crack analysis conditions suitable for 2D and 3D analysis and its solvers have been improved. Due to the change in the solvers, UI of pre-processor is also updated. The criteria for element removal in 2D and 3D crack analysis are as follows:

2D: $w_1 D + w_2 \frac{\sigma_1}{\bar{\sigma}} + w_3 \frac{D\sigma_1}{\bar{\sigma}} + w_5 \frac{\dot{\bar{\varepsilon}}}{\dot{\bar{\varepsilon}}_{max}} > D_{cr}$

3D: $D > D_{cr}$ & $\dot{\bar{\varepsilon}} > \dot{\bar{\varepsilon}}_{cr}$ & $\dot{\bar{\varepsilon}} > w_5 \dot{\bar{\varepsilon}}_{max}$

where D: damage,
D_{cr}: critical damage,
w_i: weight,
$\bar{\sigma}$: yield stress,
σ_1: maximum principal stress,
$\dot{\bar{\varepsilon}}$: effective strain rate,
$\dot{\bar{\varepsilon}}_{max}$: Maximum effective strain rate.

Figure 3.3 shows new input dialog of crack analysis.

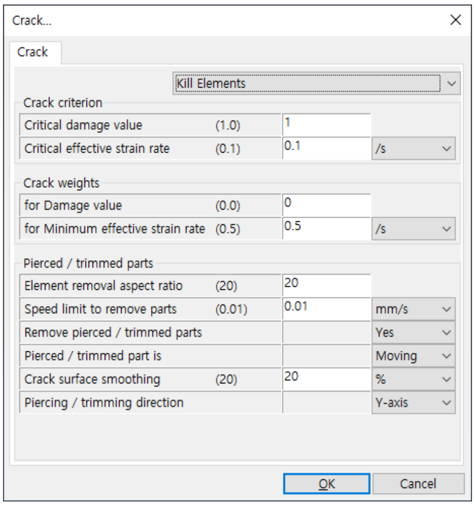


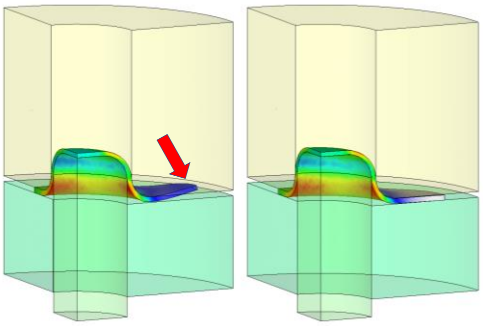
Figure 3.3 New crack analysis input dialog

3.4 Binder Feature in Plate Forging Analysis

Plate forging often uses binder which applies a blank holding force. Recently, the binder feature, which requires for unloading, has been greatly enhanced from AFDEX_V21R03 to AFDEX_V23R01 beta version. However, when a workpiece undergoes severe plastic deformation, malfunction of a binder or penetration of a material into the binder have been found and improvements in these problems are currently being made.

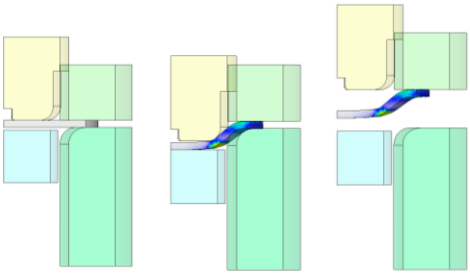
Figure 3.4 shows an error that occurs when the maximum compression distance of the binder is reached, and a remedy for abnormal penetration of the material into the die. Before the improvement, the material penetrated while the contact condition between the material and the binder is satisfied after the improvement.

Figure 3.5 is an example of the other error that the material rises while sticking on an upper die (Figure 3.5(a)), which is currently fixed by improving the nodal separation condition (Figure 3.5(b)).

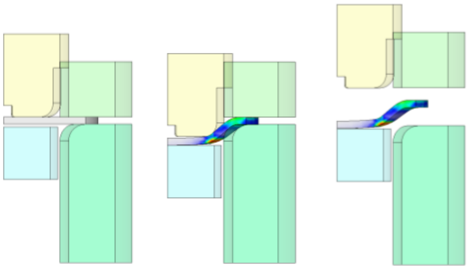


(a) Before improvement (b) After improvement

Figure 3.4 Improved binder feature



(a) Before improvement



(b) After improvement

Figure 3.5 Improvement of binder feature for unloading

3.5 Reduced Loading Time for Opening STL File

In the case of a large STL files or a large input file during Stage-by-stage continuous analysis, the loading of the pre-processor takes long. In the new version, the loading time of the large STL file had been dramatically reduced. For example, the loading time of about 1GB STL file shown in Figure 3.3 was reduced from 110sec to 30sec.

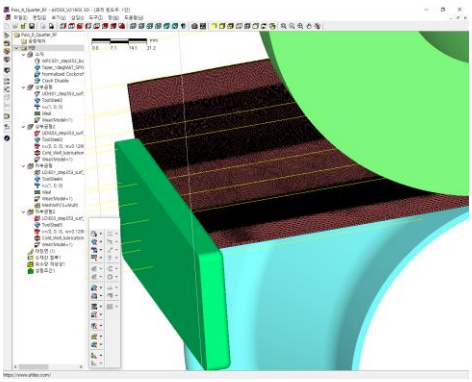


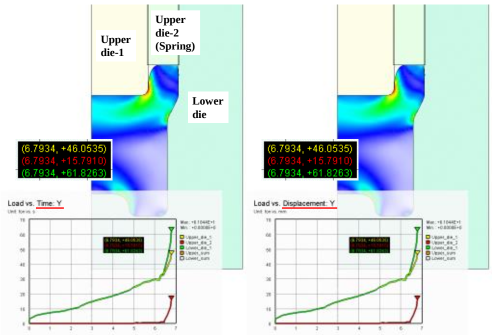
Figure 3.6 Loading large STL file

3.6 Load-Displacement Graph View Feature

Previously, a displacement of die in load-displacement curve has been defined as the sum of maximum relative distance of die obtained in each step. It has been difficult for users to estimate the displacement when running the simulation using a binder with unknown velocity.

In new version, the maximum value among the distances of each die moved except binders will be used as a displacement in the Load-Displacement.

Figure 3.7 is an example using a die with a spring attached to Upper Die-2. In older versions, time and displacement (the absolute value of maximum velocity is 1mm/s) did not match due to the relative displacement of binder. In AFDEX_V23R02, the values of time and displacement are the same as shown in Figure 3.7.



(a) Load vs. Time (b) Load vs. Displacement

Figure 3.7 Load - Time and Load - Displacement graph

4. Notice

4.1 Online Training in 2023

The tutorials and theories are uploaded on MFRC's YouTube channel. The following subjects will be provided: mathematical background, tensile testing, statics, solid mechanics, introduction to plasticity theory, finite strain, finite element method, and all materials related to metal forming, etc. Although the online lectures originally aim to help college students understand the materials, it can also be utilized as the materials introducing theories and mechanics used in AFDEX. For more details, please refer to the link below.
(https://www.youtube.com/c/AFDEX)

4.2 AFDEX Offline Seminar in Indonesia

AFDEX offline seminar was held on 15 June at Cikarang, Indonesia, which was organized by our new partner in Indonesia, Arisma Data Setia. In this event, AFDEX was introduced to the customers in Indonesia. The key topic of the seminar was AFDEX application such as cold and hot forging, hammer forging, and so on. Also, MFRC team had an open Q&A session with the participants after the presentation.

Figure 4.1 AFDEX seminar organized by Arisma Data Setia