AFDEX
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Newsletter
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**Contents**



## 1. AFDEX_V24R02 release

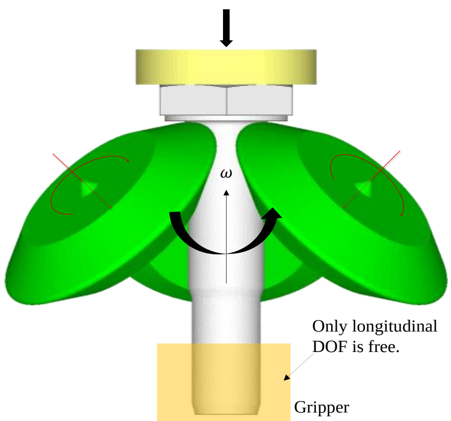
AFDEX_V24R01 was released in October 2024, and its key features were introduced in the Q1 2025 newsletter. Following this release, a new version, AFDEX_V24R02, with additional features and improvements, is scheduled to be released in May 2025.

## 2. AFDEX Applications

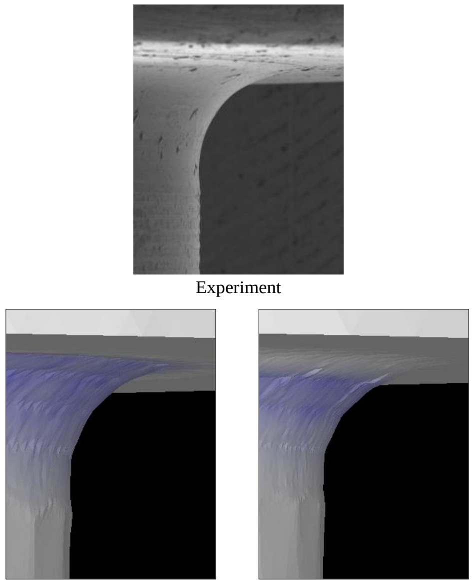
### 2.1 High-precision, cost-effective fillet rolling model

Fillet rolling is applied to impose compressive preload on safety-critical components that require high durability. Fig. 2.1(a) shows the full finite element (FE) analysis model for simulating fillet rolling of an aerospace bolt. From a simulation perspective, the key challenges are the computation time and the sensitivity of the contact conditions. In the actual process, three rollers are allowed to oscillate dynamically to maintain force equilibrium. However, in finite element simulation, the contact behavior is highly sensitive, making it essential to apply boundary conditions that prevent lateral movement of the workpiece. The application of such constraints inevitably causes an imbalance in the loads acting on the three rollers, which in turn leads to excessive localized plastic deformation at the contact surfaces.

The issue with the full-domain fillet rolling analysis model was found to be addressed by a practical model that considers only one-third of the domain. Measurements of the fillet rolling corner radius showed that the practical model aligns better with experimental results compared to the full-domain model (Fig. 2.1(b)).

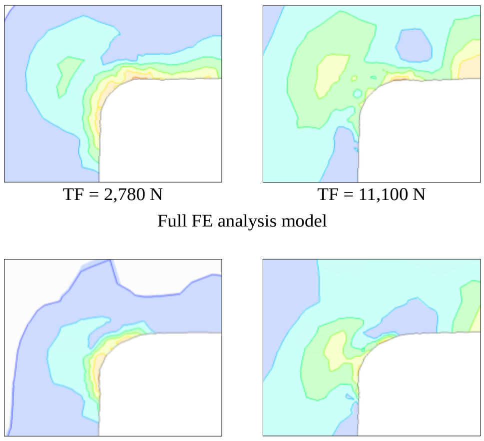


(a) Full-domain prediction model


Experiment

Full analysis model | Practical analysis model

(b) Experiments and full-domain and practical model predictions


TF = 2,780 N | TF = 11,100 N

Full FE analysis model

TF = 2,780 N | TF = 11,100 N

Practical FE analysis model

(c) Fatigue life test analysis

Fig. 2.1 Practical model for fillet rolling process analysis

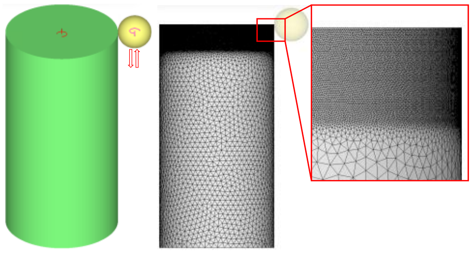
In the case of the full-domain analysis model, as seen in the effective residual stress analysis under low and high loading conditions during the fatigue life test (Fig. 2.1(c)), the influence zone of fillet rolling appears to be somewhat wider than that of the practical model.

Detailed findings related to this topic will be presented in academic papers and other related publications.

### 2.2 Ball burnishing simulation

Burnishing is a surface finishing process in which the inner or outer surface of a cylinder is pressed with a ball to smooth the surface, and it is a special case of metal forming. This process offers various advantages such as improved surface finish, increased wear resistance, enhanced dimensional consistency, and better corrosion resistance. In this process, as the ball applies micro-scale compression to the surface, the simultaneous rotation of the workpiece and the tool, along with the linear motion of the tool, requires special functions for finite element analysis. In particular, ultra-precise meshing capable of representing micron-level accuracy is necessary (Fig. 2.2(a)). Fig. 2.2(a) shows the initial mesh model created using 1.5 million elements, with dense discretization applied to the region in contact with the ball.

Additionally, because the burnishing process involves significant rotation of the workpiece, it can be exposed to numerical volume distortion during analysis. Appropriate techniques must be applied to address these issues. Fig. 2.2(b) shows the analysis results using specialized functions.


(a) Mesh model

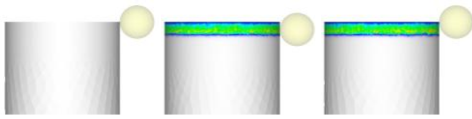

(b) Deformation history

Fig. 2.2 Analysis of ball burnishing process

### 2.3 Scientific and informational approach to tensile test results

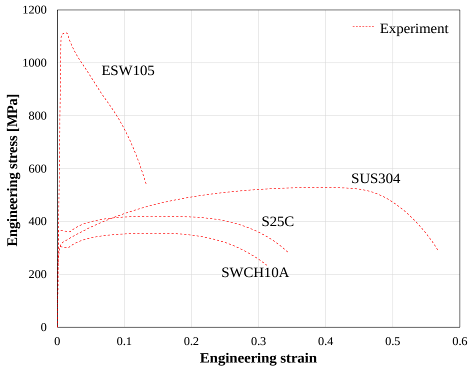
Tensile test is very important for both understanding of metal forming and acquiring material's flow information. One of the key factors in the tensile test is the gage length per diameter (GLPD). This is standardized internationally as 4 or 5. However, due to various factors, it is often difficult to maintain this standard. The elongation, which greatly affects material formability and workability, varies depending on the GLPD, even for the same material. Therefore, securing standardized tensile test results and accumulating such data are necessary, whether at the individual or corporate level.

To resolve this issue, an analytical elongation calibration function has been developed, and its validity has been numerically verified (Kim et al., 2025, Mater. & Design, 113851). By using this elongation calibration function, which is a type of mapping function, nominal stress–nominal strain curve data obtained from non-unified tensile specimens as shown in Fig. 2.3(a) can be converted into standardized tensile test data with GLPD = 5, as shown in Fig. 2.3(b).

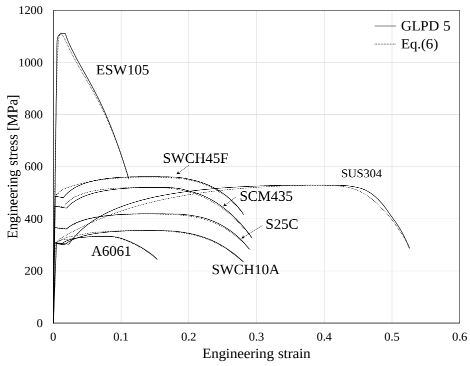
It should be emphasized here that differences in elongation arise depending on the GLPD, and as can be seen from the comparison of Fig. 2.3(a) and Fig. 2.3(b), such differences can be significant depending on the material. For instance, in the case of ESW105, which has low strain hardenability, the difference is especially large.

Meanwhile, Fig. 2.3(b) compares virtual tensile test results (GLPD = 5) obtained using the elongation calibration function and the finite element method. The two results show very good agreement. In Fig. 2.3(b), materials such as A6061, SCM435, and SWCH45F followed the GLPD = 5 standard in the experiments, and the experimental results matched the virtual tensile test results. The good agreement between the analytical and experimental tensile test results validates the material flow function used.

Understanding of the tensile test is important in metal forming and metal forming simulation. To enhance this understanding, AFDEX provides a variety of functions and related information.




(a) Tensile tests under different GLPDs




(b) Unified virtual tensile test with GLPD = 5

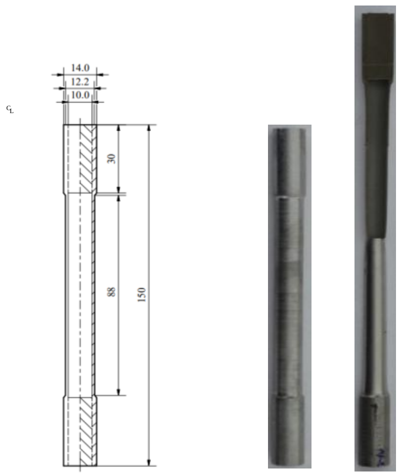
Fig 2.3 Scientific and informational approach to tensile test

## 2.4 Method for obtaining flow curves from tube materials

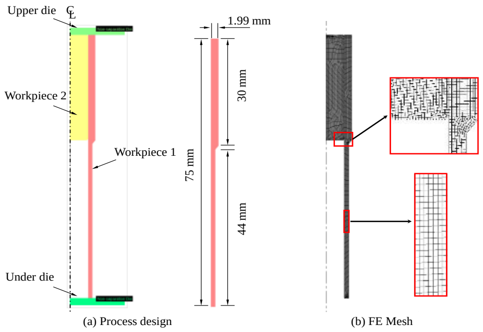
Various studies have been conducted to obtain flow functions from solid bar materials. In the case of AFDEX, the software provides an easy way to acquire flow stress from tensile tests through AFDEX/MAT.

However, for tube materials, despite the contributions of many researchers, there are still practical limitations. Many studies have adapted the sheet tensile testing method, while some have attempted to acquire flow stress using tight-fitting plugs. Although the plug-fitting method is generally known to offer high accuracy, unlike solid bar tensile testing, it is not possible to ensure a stable gage mark, and the area near the grips is inevitably exposed to severe plastic deformation due to strain hardening.

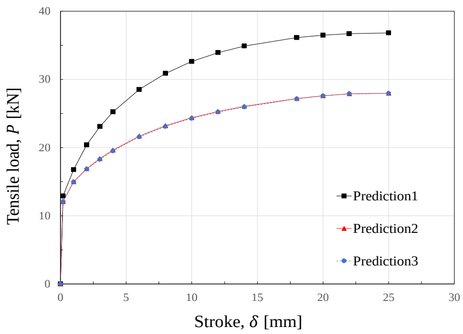
To address this, a method was developed to obtain flow curves by integrating finite element method with tube tensile testing. In this method, as shown in Fig. 2.4(a) with the specimen design and actual specimen, the radius of the main deformation section was removed by turning to induce plastic deformation concentrated in the main deformation section. As shown in Fig. 2.4(b), the finite element analysis model was designed based on multi-body analysis techniques, with minimal assumptions, to closely match the actual tensile test.



(a) Specimen design and test results




(b) Finite element analysis model of tube tensile test




(c) Stroke–tube tensile load curve

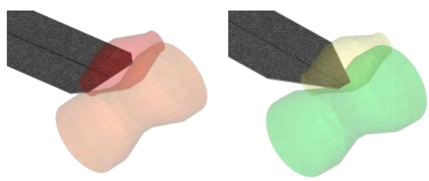
Fig. 2.4 Process-level flow curve acquisition for tube materials

The developed method iteratively refines the flow curve. In this example, despite a large difference between the initial and optimal flow curves, after two iterations of optimization, an accurate flow curve (error of 0.16%) was acquired, as shown in the stroke–tube tensile load curve in Fig. 2.4(c). The flow curve itself is not presented here; only the resulting curve is shown.

## 2.5 Roll forming simulation

In roll forming, the velocity boundary condition is a critical factor. Accurate forming analysis is only possible when the material feeding speed in the forming direction matches the roll rotation speed. If this condition is not met, issues like frequent mesh regeneration and deformation of the entering material shape may occur.

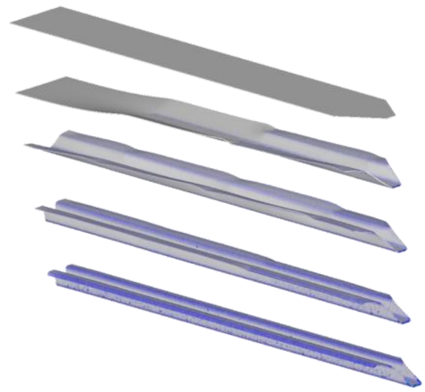
In AFDEX_V24R02, a 10-stand roll forming process was simulated considering these input conditions. Especially, as shown in Fig. 2.5(a), the initial material shape was modified to allow smooth entry between the first upper and lower rolls. As a result, the simulation of the 10-stand roll forming process was completed stably, as illustrated in Fig.s 2.5(b)–(d).



(a) Before and after initial material shape modification

(b) 10-stage roll forming process

(c) Flower pattern



(d) Shape evolution of material

Fig. 2.5 Simulation results of 10-stand roll forming

# 3. New and Improved Features in V24R02

## 3.1 Library search in pre-processor

Starting from AFDEX_V24R02, a library search function has been added for materials, presses, and friction conditions. Users can search by keywords and apply the corresponding simulation conditions. As shown in Fig. 3.1, the library search window is activated.

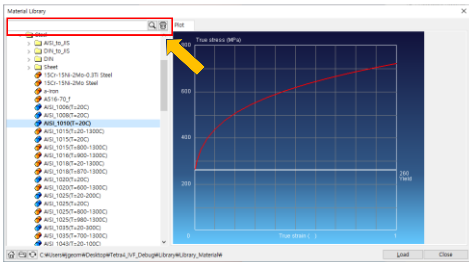


Fig. 3.1 Library search UI

## 3.2 Weight calculation in pre-processor

From AFDEX_V24R02, if the material density is input, the weight of the model can be calculated. This function is available under the auto weight tab in the material or die modeling property window. As shown in Fig. 3.2, after entering the density in the pre-processing window, the calculated result can be confirmed.

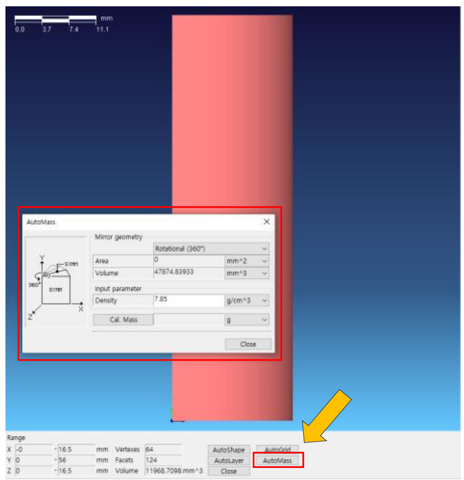


Fig. 3.2 Automatic weight calculation UI

## 3.3 Improved 3D piercing/trimming functions and added input window images

In AFDEX 3D, piercing or trimming is conducted based on the die with applied velocity. Users unfamiliar with this feature often make mistakes when setting up these processes. To support understanding and reduce errors, images have been added to the simulation input window. Additionally, there have been occasional reports of simulations ending without performing piercing or trimming. This issue has now been improved. Fig. 3.3 shows the newly added images in the input window for piercing and trimming.

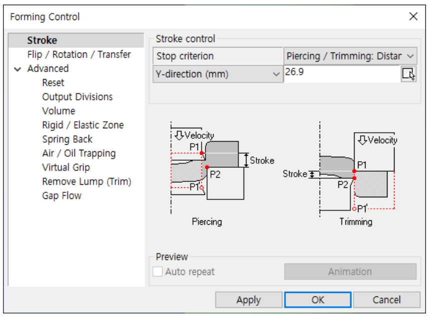



Fig 3.3 Input window for piercing/trimming conditions

## 3.4 Material-to-material friction input for single-object simulations

In previous versions, when material-to-material contact occurred in single-object simulations, the solver internally calculated the friction conditions between materials. Starting from AFDEX_V24R02, friction conditions between materials can now be explicitly defined not only in multi-object simulations but also in single-object ones.

Fig. 3.4 shows the window where users can define friction conditions and friction coefficients between materials.

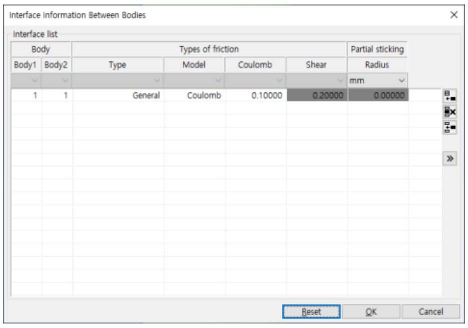



Fig. 3.4 input window for material-to-material friction conditions

## 3.5 Auto element count for 2D simulations

To enhance user convenience, AFDEX automatically sets analysis conditions. In the process information input window, users can select from high speed, normal, or precise options for balancing calculation speed and accuracy. Based on this selection, the number of elements and analysis steps are automatically calculated and stored in the input file. Starting from AFDEX_V24R02, these values are increased by 1.5 times compared to previous versions. Users who rely on auto settings should take this change into consideration.

## 3.6 Improved metal flow line view for arbitrary directions

In previous versions, viewing metal flow lines was inconvenient if the initial placement of the material did not align with the x-, y-, or z-axes. In AFDEX_V24R02, an auto-detection feature for the central axis has been added. This improves the visibility of metal flow lines regardless of the material's orientation. As shown in Fig. 3.5, the visibility of flow lines for tilted materials has been significantly improved.

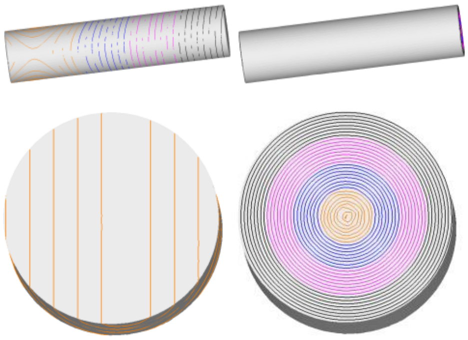


Fig. 3.5 Improved view of metal flow lines

## 3.7 Refined GUI for heat treatment module

The heat treatment module in AFDEX has reached its final development stage and is set to be released soon. Based on feedback from beta testing, several pre-processing GUI improvements have been made.

Key GUI improvements are as follows: When creating a new project, sample heat treatment processes are preloaded to enhance user convenience (Fig. 3.6). The heat treatment dialog now includes a chart to visualize the heat treatment cycle (Fig. 3.7). In the cycle dialog, users can input analysis steps, options, and heat transfer boundary conditions for each cycle (Fig. 3.8).

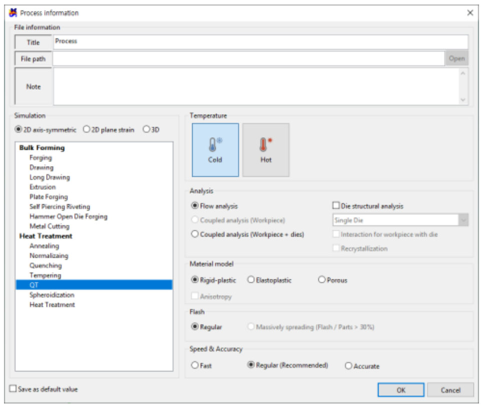


Fig. 3.6 Process control – heat treatment sample

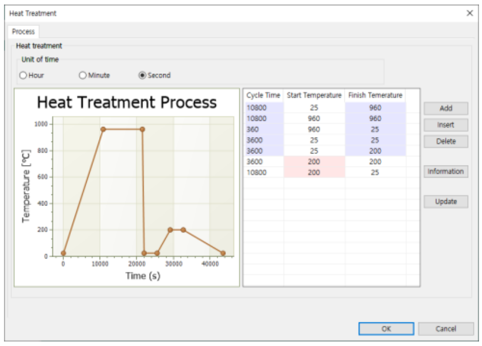



Fig. 3.7 Setup dialog – heat treatment

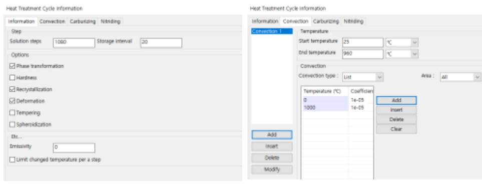


Fig. 3.8 Information dialog - heat treatment cycle