AFDEX
Adviser for metal Forming process Design EXpert
Newsletter
Q3 / 2024
MFRC
Metal Forming Research Corporation
www.afdex.com, mfrc@afdex.com
Tel: +82-55-755-7529, Fax: +82-55-761-7529

**Contents**



## 1. AFDEX_V24R01 Release

The_V24R01 will be released on this September. Details about new and improved features are described in AFDEX Newsletter Q2 2024, sections 2 and 3.

## 2. New Feature in AFDEX_V24R01

### 2.1. Calculation of Anti-Lubricant Strain

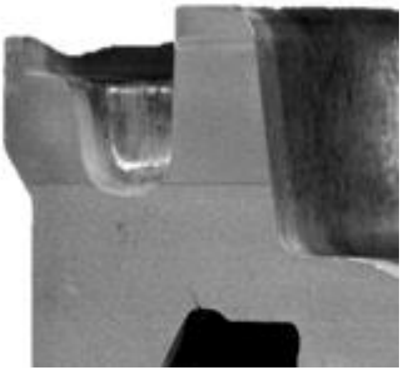
Frictional stress is determined by either the constant shear friction law or Coulomb's friction law. The constant shear friction law assumes that frictional stress acts with a constant value, which is considered inadequate for actual metal forming processes. Coulomb's friction law states that frictional stress is proportional to the normal stress on the contact surface. If the condition of the frictional surface remains unchanged, this law can be considered quite similar to real processes.

However, in metal forming processes, especially in forging, the condition of the frictional surface changes rapidly. Therefore, it is difficult to accurately reflect the complex phenomena in actual process with a constant friction coefficient. We strongly recommend the users who believe that using a constant friction coefficient poses no issues should examine the other types of friction law as well.

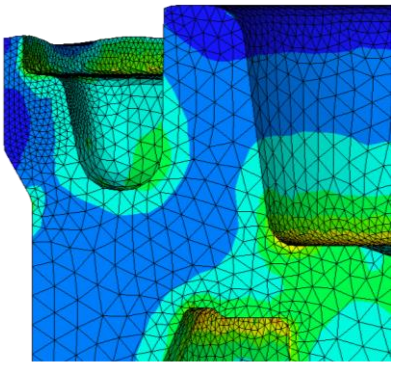
When applying the traditional Coulomb's friction law to steel forging simulations, it is very useful from a macroscopic perspective. However, friction needs to be carefully considered for more precise quantitative prediction of wear and high-precision forming loads.

Unlike steel, Aluminum alloys exhibit significant flow stress softening during forging due to low strain hardening or a temperature effect. In such cases, friction has a substantial impact. Lee et al. [S. W. Lee, J. M. Lee, M. S. Joun, 2020, On critical surface strain during hot forging of lubricated aluminum alloy, Tri. Int. 141, 105855] demonstrated that the friction coefficient in Aluminum hot forging process depends significantly on the surface strain of the material, with a sharp increase in the friction coefficient observed at a certain level of surface strain. And Hamid et al. [N. A. Hamid, K. M. Kim, T. M. Hwang, J. M. Choi, M. S. Joun, Tribological shifting phenomena during automatic multistage cold forging of an automotive Al6082-T6 steering yoke, Journal of Manufacturing Processes, V. 114, 2024, 178-195] has also revealed similar phenomena in automatic multistage cold forging of an automotive steering yoke.

Figure 2.1 compares experimental and predicted profiles of lateral wave patterns in cold forging of Aluminum alloys. The figure shows a clear agreement between actual experiments and predictions. Simply considering the material surface strain on the contact surface alone does not yield accurate results. However, by considering the extent of lubricant damage on the friction surface, predictions that match experimental results can be obtained.



(a) Experiment



(b) Prediction (Effective strain)

Figure 2.1 Outer shape prediction for wave patterns using anti-lubricant strain

Figure 2.2 shows the analysis results of the anti-lubricant strain provided in V24R01.

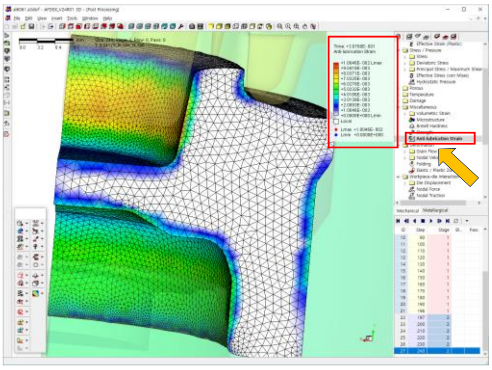


Figure 2.2 Simulation result of anti-lubricant strain

### 2.2 Decoupled Die Structure Analysis

Up to V23R02, die structure analysis was performed concurrently with material forming simulation. Even if you only wanted to perform die structure analysis, material forming simulation had to be conducted as well.

In V24R01, a new method of die structure analysis has been added that allows die structure analysis to be performed independently of material forming simulation. This feature is very useful for optimizing die designs, as it enables various die structure analyses on completed process designs.

Figure 2.3 presents the basic concept of this feature. The upper part of the figure shows a simulation result where material forming and die analysis were conducted together.

The two lower images display the results of die structure analysis performed independently by utilizing contact stresses obtained from the material forming simulation of the initial simulation and by varying the die design. This feature enables optimized die design.

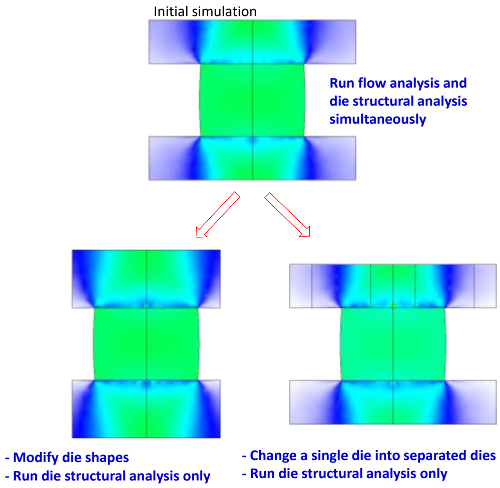



Figure 2.3 Independent die structure analysis feature

### 2.3 Stabilizing Result according to Simulation Step Size

The step size has a numerical effect on the simulation results. In this update, optimal numerical technique has been applied to minimize this numerical effect.

While this numerical influence is difficult to detect in general forging processes, it can be clearly observed in a tensile test due to their significant sensitivity to necking phenomena. This update enhances the capability to characterize material flow properties and brings substantial improvements to tensile testing analysis using the elastoplastic finite element method. Figure 2.5 shows that the results of the tensile test finite element analysis are very similar to the experimental results.

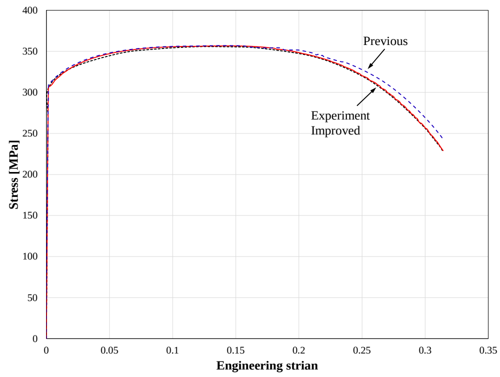



Figure 2.4 Comparison of experimental results and finite element analysis results for tensile test

## 3. Improvements in AFDEX_V24R01

### 3.1 STL Exporting Feature Improvement

In the previous version V23R02, when performing STL export operations, multiple objects were saved in a single file. This could cause an error when using software that does not support controlling multiple objects. V24R01, as illustrated in Figure 3.1, the feature has been updated to selectively save each object with a different file name.

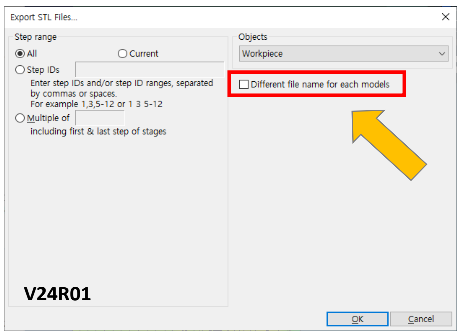



Figure 3.1 Improved STL exporting dialog box

## 3.2 Binder Load Improvement

Previously, the load imposed on a binder should be given as a function of absolute time or distance. In V24R01, the binder load can be also given as a function of relative displacement between the binder and dies.

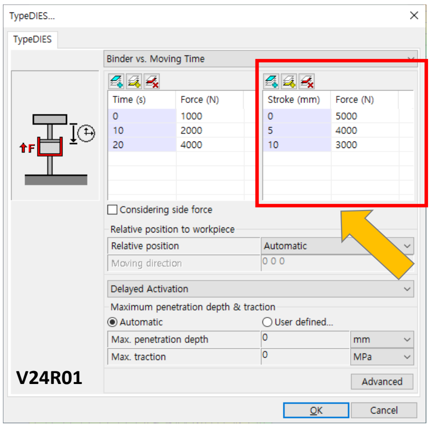



Figure 3.2 Example of Binder Load Information Input

As shown in Figure 3.2, the input window has been updated. It allows input of load information related to various conditions of binder/spring dies, such as compression distance or relative displacement.

## 3.3 Reduced Analysis Time (Rotating Dies)

Previously, when using a rotating die, excessive time needed to check the contact region. As a result, computational efficiency of processes using rotating dies such as roll forging and pilgering was significantly lower compared to other processes.

In V24R01, simulation time has been reduced by optimizing the feature checking contact region. Figure 3.3 compares simulation times for roll forging processes between the previous and latest versions.

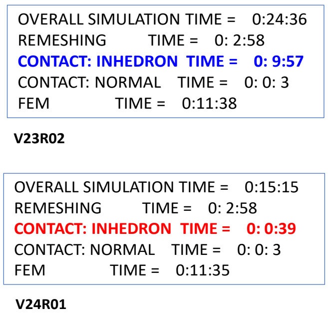



Figure 3.3 Comparison of simulation time

## 3.4 Multiple Monitors Support

When using multiple monitors, AFDEX popup dialogs intermittently did not function. To address this issue, the AFDEX's startup position and window size have been adjusted. Additionally, AFDEX now remembers the user's current monitor settings to enhance user convenience.

### 3.5 AFDEX/MAT Updates

Numerous functions have been updated based on active feedback from AFDEX/MAT users. The update details of the improved features are as follows:

- Raw data input
- Curve fitting
- Solution step input feature for tensile analysis using cold forging 8th formula model
- Yield stress and stroke information saving feature during the creation of input files for room temperature tensile test analysis
- Data output capability in the list control window when extracting raw data from high-temperature compression test graphs

# 4. Notice

## 4.1 Online Learning in 2024

On AFDEX's official YouTube channel, the theory and usage related to metal forming have recently been significantly reorganized. You can explore tutorials on the theory of engineering plasticity and finite element methods, as well as practical applications of using AFDEX. Additionally, lectures on statics, solid mechanics, and mathematics are available for non-majors.

AFDEX's official YouTube address is as follows. (https://www.youtube.com/c/AFDEX)