AFDEX Newsletter Q1 2018

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Contents

1. AFDEX_V17 and AFDEX_V18

1.1 Summary of improved and new functions

AFDEX_V17R00/beta was released for trial on June 1, 2017. AFDEX_V17R00 was officially released on July 1, 2017 and it was revised on November 1, 2017 after verification from domestic and international experts. The main functions are listed in Table 1.1 and some of them are detailed in Section 1.2.

The release of AFDEX_V18R01 is planned to be made on February 10, 2018. Its key functions are listed in Table 1.1 and some of them are described in detail in Section 1.3. Some of the new features have been provided through AFDEX_V17 with improvements, but they will be officially available in AFDEX_V18.

Table 1.1 New functions or improvements of AFDEX_V17

	Functions or improvements
2D and 3D	-Simulation considering die elastic deformation -Simulation considering die elastic deformation with shrink fit considered -Repetitive simulation between specific steps -Simulation considering elastic deformation of press -Analysis of heat transfer among assembled dies -Structural analysis of assembled dies -Control of penetration of material into the gap between dies -Calculation of shortest distance between nodal points and dies -Improved computational speed -Improvement of node separation algorithm -Improved Brozzo damage model -Function of contact exclusion during structural analysis of assembled dies -Prediction of hardness based on experimental formula -Improved heat transfer analysis function -Improved frictional conditions as a function of temperature, pressure and strain -Improved heat transfer coefficients as a function of temperature and pressure -Local mesh density control -Function of treating the nodes which penetrate into the material -Initializing state variable for the first solution step -Improved initialization of material before being formed at the first solution step of each stage -Increased number of available dies in one stage -Function of limiting temperature increment at a solution step
2D	-Boolean operation -Process design optimization using HyperStudy -Improved determination of the final stroke when non-standard dies are employed -Improved mesh density control of dies -Die geometry defined by a connection of die points -Improved description of dies
3D	-Improved computational speed -Improved function of pusher in open-die forging including rigid body condition -Improved algorithm of step size and contact for open-die forging -Improved mandrel control for swaging, radial forging, and open-die forging -Improved algorithm for separating contact node -Improved temperature analysis in dwelling/transferring -Addition of stroke control based on distance when axisymmetric die is used in 3D -Improved rotating die function -Improved non-isothermal analysis of a screw/hammer forging process -Hydrostatic forming function -Air trapping treatment -Improved pusher for open-die forging -Improved initialization of state variables -Composite material treatment -Improved function of ring rolling simulation -Evolving function of a rotating die -Specialized remeshing for ring rolling simulation -Compensation of volumetric change due to remeshing -Elementwise compensation scheme for volume change -Back pressing function of manipulator and pusher -Exactly positioning of periodically moving die -Improved 3D point tracking

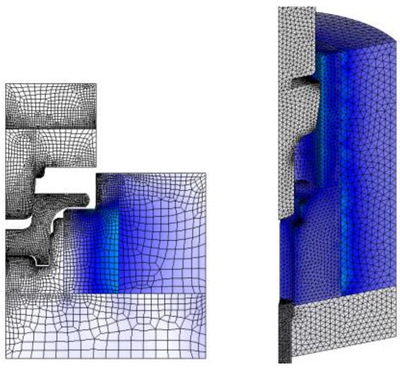
Table 1.2 Plan of adding new functions or conducting improvements for AFDEX_V18

	New functions or improvements
2D or/ and 3D	-Function for skin element generation -Function for calculating flow stress depending on compressive or tensile strain -Quantification of grain flows -Multi-body simulation for isothermal analysis -Two-step motion of die (Loading and unloading) -Sophisticated material models -Microstructural evolution prediction -Heat treatment and carburization simulation -Local heating of material -Improved structural analysis of assembled dies -Improved complete simulation -3D local remeshing

1.2 Main features of AFDEX_V17

1.2.1 Shrink fit analysis of assembled dies

Fig. 1.1 shows structural analyses of assembled dies considering shrink fit. The shrink fit analysis of an assembled die basically includes shrink fit. Die elastic deformation caused by shrink fit can be adopted in the case of no die modification or ignored in the other case. Of course, die stress regarding shrink fit is always reflected. In the figure below, effective stress contours by shrink fit on the first solution step are presented.



(a) 2D (b) 3D
Fig. 1.1 Structural analysis of assembled die considering shrink fit

The earlier 2D/ 3D function for die shrink fit was readily applicable when the contact surface between the inner surface of shrink ring and the outer surface of die were completely in contact with each other in a straight line.

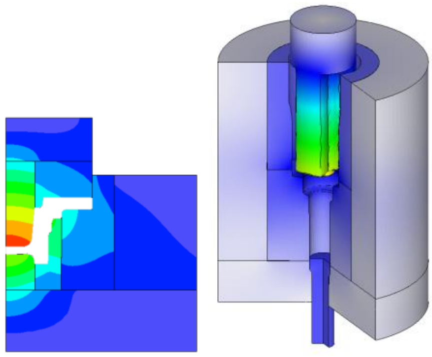
This function has been now modified and it additionally allows the user to carry out an assembled die shrink fit analysis even when the contact happens over stepped surfaces. In other words, this added function of the assembled die structural analysis is supplemented with the existing function.

1.2.2 Forging simulation considering die elastic deformation

After the version of AFDEX_V17R00/beta, the elastic die structural analysis of an assembled die is possible. However, the die deformation was not coupled to the flow analysis of material. AFDEX_V17R00(AFDEX Advanced) supports the function to consider the elastic deformation of the assembled die during metal forming simulation.

If the AFDEX Professional version is being used currently under maintenance contract, 50% of the price difference between the two versions can be paid to upgrade to the advanced version.

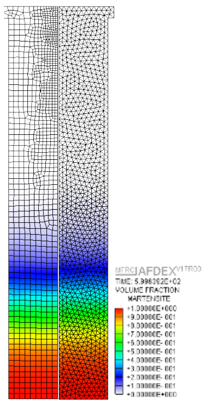
Fig. 1.2 shows examples of complete analysis of forging processes, which considers the effect of die deformation due to forming load.



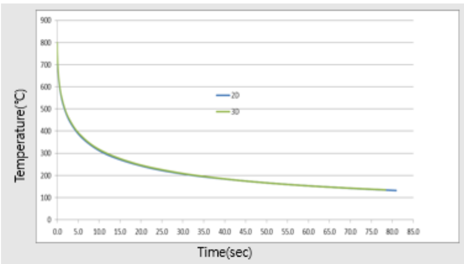
(a) 2D (b) 3D
Fig. 1.2 Simulation considering assembled die deformation

1.2.3 Heat treatment analysis

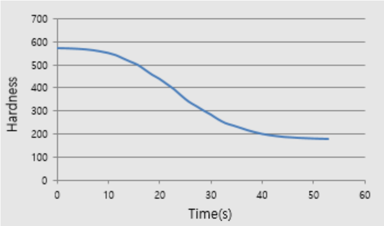
The AFDEX - HT was released on October 1st, 2017 in a selected country. Fig. 1.3 shows simulation result of a Jominy test using the 2D/ 3D heat treatment functions. Both 2D and 3D results are similar because they are all based on the stable temperature change although a quenching process was analyzed as shown in Fig. 1.3(b). Additionally, Fig. 1.3(c) shows that the hardness change can be predicted by AFDEX-HT.



(a) 2D/ 3D Jominy test (Fraction of martensite)



(b) 2D/ 3D temperature comparison



(c) 2D Jominy test result (Hardness)
Fig. 1.3 Heat treatment simulation of a Jominy test

1.2.4 Fortified function for ring rolling analysis

Ring rolling is representative of an incremental metal forming process which needs much computational time for simulation. Of course, it needs enhancement of solution accuracy. Importance of mesh system cannot be over emphasized for both the computational time and the solution accuracy. An optimized mesh system specialized at ring rolling is developed which meets the requirement of good contact between material and dies as well as minimal number of remeshings. Fig. 1.4 shows the usefulness of the capability, i.e. mesh systems with torus-type densified mesh automatically generated considering the contact interface.

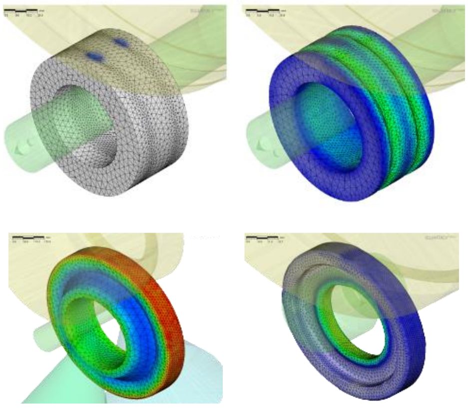
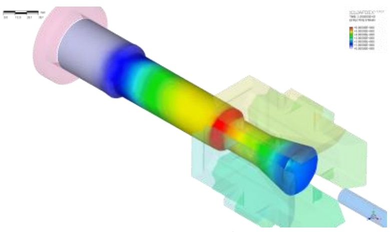


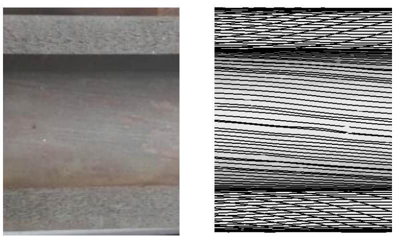
Fig. 1.4 Finite element analysis of ring rolling process with enhanced mesh generation scheme

1.2.5 Improvement of free forging, radial forging and swaging

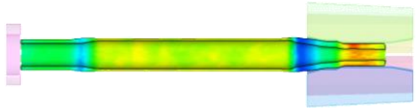
Recently, radial forging and swaging, which are a kind of open-die forgings, are being widely applied to meet the current demands for lightweight design. To cope with this, the functions of open-die forging, have been greatly improved with modifications including the mandrel treatment. Fig. 1.5(a) shows a warm radial forging process and Fig. 1.5(c) shows a swaging process. Both processes used mandrel for shaping the inner surface of hollow stepped bar. Fig. 1.5(b) compares the experimental results with the analytical results for the warm radial process, revealing that the metal flow lines inside the hollow shaft agree well with each other. Fig. 1.5(c) shows the results of the 6-stage swaging process obtained using the improved swaging process function.



(a) Warm radial forging



(b) Comparison of experiments



(c) Swaging
Fig. 1.5 Radial forging and swaging

1.2.6 Distance calculation function

From AFDEX_V17R00, the function calculating the distance from the node of material to the nearest die and the function calculating material thickness has been provided. Fig. 1.6 shows the material thickness variation of 3D plate forged material.

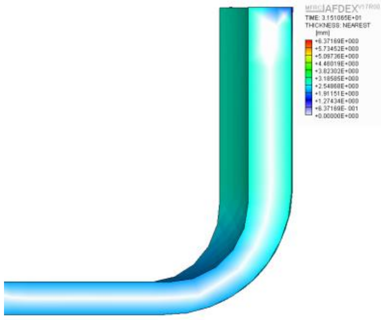
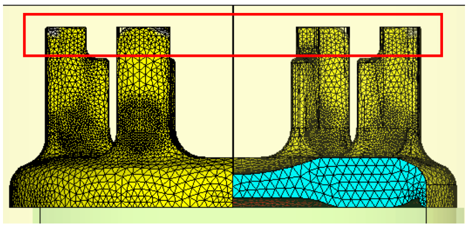


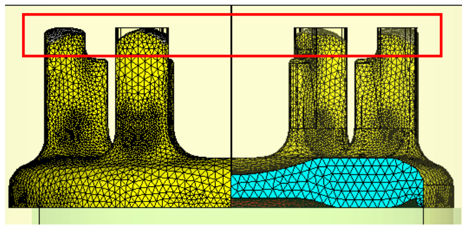
Fig. 1.6 Thickness distribution

1.2.7 3D air pocket or trapping analysis

The 2D analysis function considering air pocket has been provided since 2012. From this latest release, AFDEX_V17R00, 3D function of air pocket analysis will also be offered. Figure 1.7 shows the comparison of simulation results with and without consideration of air pocket.



(a) Without air pocket

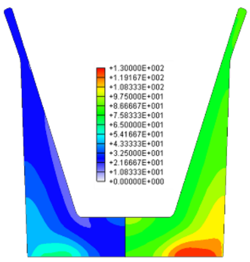


(b) With air pocket
Fig. 1.7 Effect of air pocket

1.3 New features of AFDEX_V18

1.3.1 Microstructure evolution

A deeper understanding of metallurgical phenomenon is the most important pre-requisite in properly predicting metallurgical evolution under the variation of influential parameters such as temperature and velocity field. Henceforth in the early phase of process design, it is quite vital to use such a software tool capable of describing the metallurgical evolution. This feature will be released in March 2018. Fig. 1.8 shows an example of microstructure prediction.



Recrystallized part Grain growth part
Fig. 1.8 Grain size prediction

1.3.2 Carburizing process

An improved special function for the carburizing process will be released in March 2018. For this analysis, the remeshing technology which generates a dense surface mesh has been greatly improved. Fig. 1.9 is a typical application.

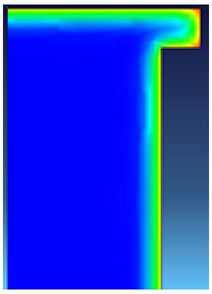


Fig. 1.9 Prediction of carburizing process

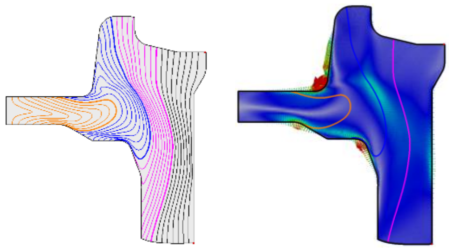
1.3.3 Quality indices of metal flow lines

The metal flow (grain flow) lines have a significant effect on the life of the forged product. According to research (Ito et al.), the tests on tapered roller bearings indicated that products with good metal flow lines have up to 6 times longer life than products with non-optimized ones. It has been well known (Refer to the conference book of MFCAE 1996, edited by M. S. Joun or AFDEX homepage) that SKF strictly require the symmetry of the first-generation hub bearing outer race.

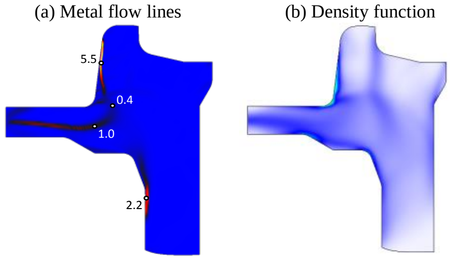
Until now, there was no other way to determine the quality of metal flow lines. This problem has been a great obstacle to optimize the design of the metal forming process design using a metal forming simulator. In other words, when defining the process design optimization problem, it was not possible to treat metal flow lines directly as an objective function or constraint.

Recently, the quality indices of these metal flow lines have been developed, including the density function of metal flow lines and its overlapping index. Fig. 1.10 shows the application examples. Fig. 1.10 shows that the possibility of overlapping was well described by the overlapping index recently developed for AFDEX. However, comparison of Fig. 1.10(c) with Fig. 1.10(d) shows no similarity between the overlapping index and effective strain, emphasizing the importance of the index.

Note that overlapping of the metal flow lines can be prevented by minimizing or controlling this index. The same approach applies to both 2D and 3D.



(a) Metal flow lines (b) Density function



(c) Overlapping index (d) Effective strain
Fig. 1.10 Metal flow lines and quality indices

1.3.4 Future-oriented innovation of the program

Recently, the fundamental structure of AFDEX program has been enhanced greatly for supporting new addition of functions and improvement of computation efficiency. In other words, AFDEX has a single program structure that is systematically combined with mechanical, thermal and material engineering analysis functions. As a result, improving new features will be accelerated, and reduction will be made in terms of calculation time. In the next version, significant progress will be made in terms of analysis of very large problems, process optimization, metallurgical analysis, and high-speed computation.

In the version of AFDEX_V18, a dramatic improvement in computation speed will be provided. The computational time at present for non-isothermal analysis of a typical process became 30 % that in the past. This will lead to the improvement of the process optimization function and the applicability with the increase of the utility of the program.

The example to be tested is the 3D upsetting process, which consists of a dwelling process, a forging process, and again a dwelling process. The analysis is simulated by flow analysis, temperature analysis and die structural analysis. It takes about 50 seconds to get the result by the latest version while the previous version took 140 seconds. A continuous research works on further reduction of computational time is being conducted and thus additional reduction of the computational time is expected in the next version.

On the other hand, the previous and current version of AFDEX has also been a strong point in market with excellent efficiency in calculating metal flow lines and special functions of automatic simulation of multi-stage process and simultaneous simulation of multiple processes in a computer.

2. Presentations or publications

2.1 Application-oriented papers

Table 2.1 shows the conference papers published by the AFDEX development team in 2017. A total of 27 papers have been published and some representative examples are given in Sections 2.2.1~2.2.6. Other AFDEX new features and enhancement applications and papers can be found at the following link. (http://www.afdex.com/)

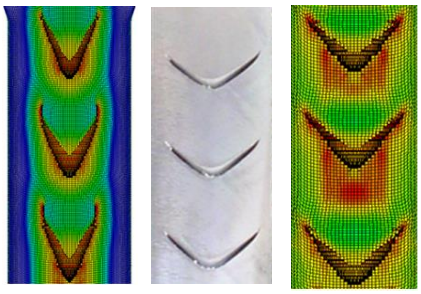
Table 2.1 List of application-oriented papers

Spring Meeting 2017, Kor. Soc. for Tech. of Plasticity	
1	Predictability of chevron crack by theory of conventional ductile fracture 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 non-axisymmetric cold forging
Fall Meeting 2017, Kor. Soc. for Tech. of Plasticity	
12	Quality of grain flow of metal formed products
13	A numerical simulation of the Jominy end-quench test
14	Consideration of validity of non-isothermal analysis using skin-elements
15	Complete FE analysis of a simultaneous hot forging process of inner race and boss of auto transmission
16	Study on ductile and shear fracture during metal forming considering stress tri-axiality
17	Die life prediction in hot forging
18	Estimation of temperature change of dies during forging by repeated analysis
19	Study on friction in aluminum cold forging
20	Precision finite element analysis of an inner diameter expansion process for stainless seamless pipe
21	Prediction of chevron crack during a multi-stage open cold extrusion process
22	Simulation of high-speed and precision radial forging process
23	Flow stress identification from cold compression test using finite element method and optimization technique
24	A study on optimization of die shape parameters of a forging process using AFDEX and HyperStudy
25	Practical finite element analysis of a flow forming process
26	Obtaining parameters of dynamic recrystallization kinetics using FEM and optimization technique
27	Prediction of carburized case depth and distortion during carburization heat treatment

2.2 Details of selected presentations

2.2.1 Predictability of chevron crack

Most researchers have used the normalized Cockcroft-Latham damage model. However, it exhibits significant difference in defect shape from experiments, as shown in Figs. 2.1(a) and 2.1(b).

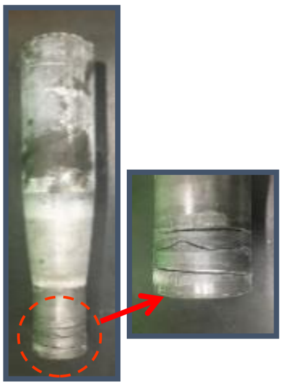


(a) Prediction 1 (b) Experiment (c) Prediction 2
Fig. 2.1 Experiment and prediction of chevron crack

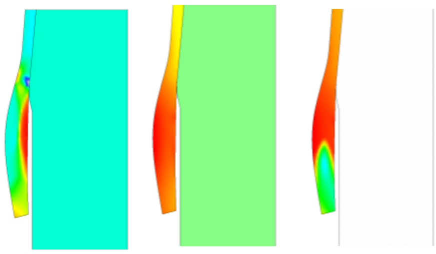
Fig. 2.1(c) shows the prediction of chevron crack occurring in an open multi-stage extrusion process obtained by a modified way. This study emphasizes the drawbacks of the Cockcroft-Latham damage model, which has a weak point in reflecting the effect of compressive stress on the fracture.

2.2.2 Fracture 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 article deals with a brittle fracture shown in Fig. 2.2 occurring just after the fracture region passes through the exit in a cold shell nosing process undergoing more compressive plastic deformation. It was 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.



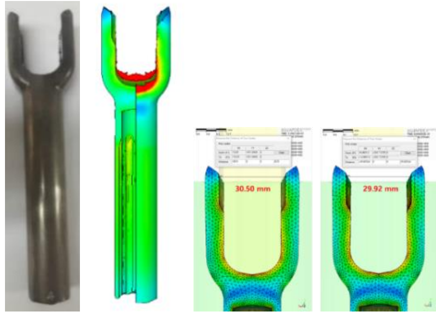
(a) Experiments



Principal stress Yield strength Effective stress
(b) Predictions
Fig. 2.2 Fracture in a shell nosing process

2.2.3 Analysis of Springback and its verification

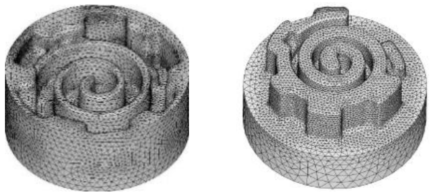
This study predicts the change in distance between two ears of a yoke due to Springback during unloading process after being forged by automatic multi-stage precision forging, as shown in Fig. 2.3. The change in the distance was predicted 0.50mm and that of the experiment was 0.58mm, which indicates that they are quantitatively in good agreement.



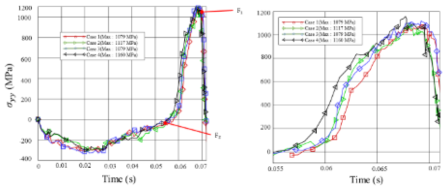
(a) Final product (b) Predicted Springback
Fig. 2.3 Precision cold forging process of yoke

2.2.4 Complete analysis of scroll forging process

The temperature and die deformation have a considerable influence on the scroll forging process shown in Fig. 2.4(a). It is thus a suitable problem to investigate further into the effect of the material and the die model. The stresses causing the failure of the die were calculated. The material is assumed rigid-viscoplastic or rigid-thermoviscoplastic and dies are assumed rigid or elastic summing up to four cases of quantitative comparison as shown in Fig. 2.4 (b). These results will help application engineers have an intuition about the effect of the theory on the predictions.



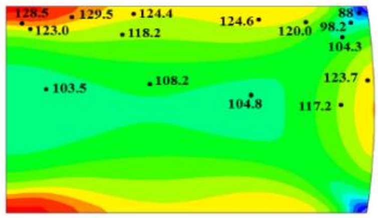
Material Die
(a) FE analysis model



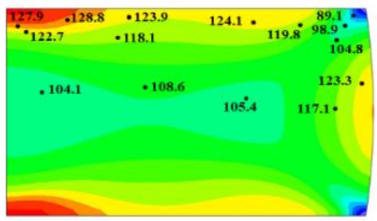
(b) Prediction of die stress from FE analysis
Fig. 2.4 Aluminum scroll forging process

2.2.5 Identification of metallurgical properties

Fig. 2.5(a) shows predictions of grain size with known material properties and Fig. 2.5(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 that the scheme of material identification for predicting microstructural evolution is powerful and economical.



(a) With known material data

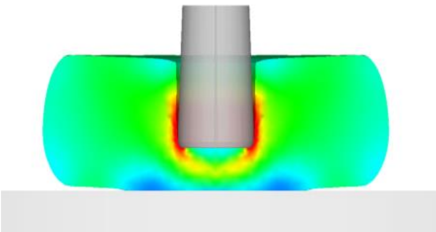


(b) With identified material data
Fig. 2.5 Comparison of predicted grain sizes

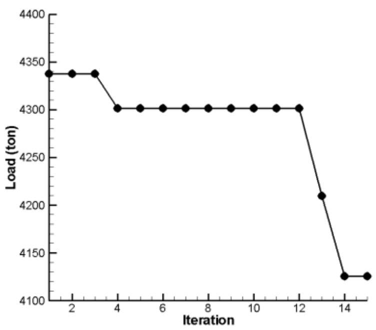
2.2.6 3D process optimal design

From 2016, it became possible to optimize the process design of two-dimensional metal forming process. There was no restriction to design 2D optimized process except considering metal flow lines. This technique was also used to obtain the material properties and process conditions required to predict microstructural changes.

Finally, the quality indices of metal flow lines are developed. However, the problem of design optimization of the three-dimensional metal forming process still needs to be solved. There remains a problem of expressing the die with appropriate design variables or parameters. At present, research on the design parameterization of the die is being carried out. Fig. 2.6 shows an example of the optimal design of a three-dimensional metal forming process in which the die is axisymmetric.



(a) Predictions of the optimized process design



(b) Forming load vs. iteration

Figure 2.6 Application example of 3D process design optimization

3. Main events

3.1 Seminar by globally renowned Professor

Prof. Shin (Purdue University) gave an outstanding seminar at GNU and participated in a cooperation research meeting with MFRC on May 23th, 2017.

The Purdue University has been using AFDEX for educational purposes for five years and has been conducting cooperative research on multi-scale microstructure evolution for 2 years, supported by MFRC. Based on the results, commercialization of multi-scale microstructure prediction technology will be carried out in the third year. Recently, research team of Prof. Shin has published the paper, "Investigation on temporal evolution of the grain refinement in copper under high strain rate loading via in-situ synchrotron measurement and predictive modeling", in Acta Materialia (5 years average impact factor = 5.6). Professor Shin Yung-Chul is a world-renowned professor whose research is cited around 1200 times per year. His main field of research activities includes laser applications and its mechanical and metallurgical properties.

Fig. 3.1 Special lecture by Professor Shin

3.2 MFCAE 2017

MFCAE 2017 organized by Gyeongsang National University was held at Changwon Pullman Hotel on August 17th and 18th. A total of 15 oral presentations and 97 poster presentations took place. More than 120 people including AFDEX developers attended this event to present their outstanding achievements and to discuss further directions of AFDEX development. Since its inception in 1996, MFCAE has been leading the technological development of metal forming CAE and the utilization of industries through 17 events and has contributed to the development of the industrial forging technologies.

Fig. 3.2 MFCAE 2017

The conference proceedings of MFCAE 2017 were published for educational purposes of metal forming simulation technology under the title of "Metal Forming Simulation – Theory and Application (Ed. M. S. Joun)" by Jinsaem Media in Korea. Eleven researchers contributed to its publication, including Prof. W. J. Chung (SNUT), S. M. Hong (KNU), K. H. Lee (PNU), Y. Shin (Purdue University), D. H. Yoo (POSTECH), M. S. Joun (GNU), S. H. Chung (MFRC) and 4 researchers working for MFRC or GNU.

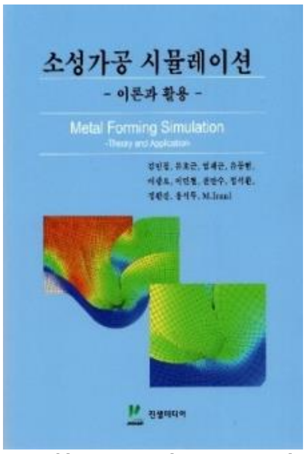


Fig. 3.3 Publication: Metal Forming Simulation -Theory and Application

3.3 GISPAM 2017

For one month from 17th July, GISPAM 2017, a special summer program for AFDEX and other engineering software was held for a scholar and 20 university students of the State of Mexico, 2 Mexican engineers, 6 GNU students and 2 Malaysian students in the Gyeongsang National University (GNU) and the Korean Mold Education Center. The program includes some selected lectures on solid mechanics and heat transfer, practice of engineering software such as AFDEX, AnyCasting, MAPS-3D, etc., industry visits and culture tours.

This GISPAM is the fourth international student exchange program, financed by the State of Mexico and related industries. However, any students, engineers and researchers from any countries who are interested in manufacturing engineering with CAE applications can join this event with the cost minimized.

Fig. 3.4 GISPAM 2017

3.4 Developers' Meeting

3.4.1 2017

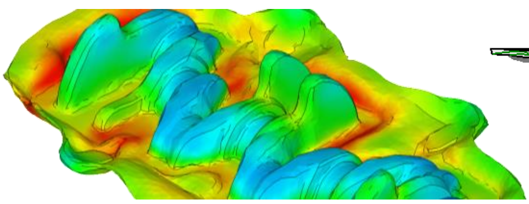
The first Developers' Meeting in 2017 was held on Jan. 6, 2017 followed by two conferences at the Korean Society of Technology of Plasticity and one at the user conference, i.e., MFCAE 2017.

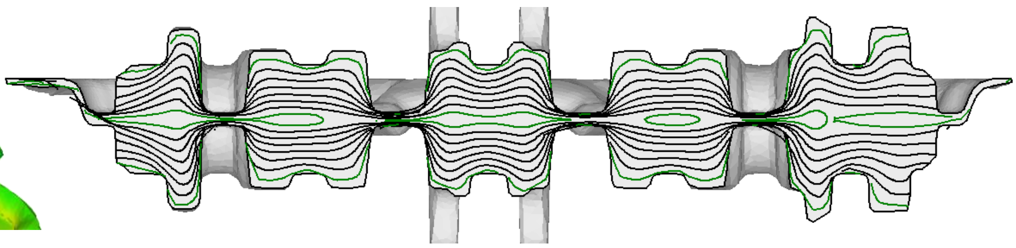
3.4.2 2018

On December 28, 2017, the AFDEX Developers' Meeting of 2018 was held at MFRC's new office (Rm. 1207-1209, Building A, Wings Tower, Jinju Korea). At the first meeting of this year, 22 researchers or research assistants attended, and there were discussions on the works carried out during the year 2017. Also, research directions for the future were discussed with emphasis on speeding up new functions and reducing computational time further. In addition, two invited seminars on die description in terms of process design parameters and practical hot stamping technology were held.

Three additional developers' meetings of the seasons including spring, summer and fall will be held in this year. AFDEX is always ready to invite any researcher or engineer as a developer who has some ideas for application.

Fig. 3.5 First developers' meeting of 2018





4. Cooperation and Communication

4.1 For induction heating module

In August 2016, a research project for the induction heating process analysis between MFRC and Pohang University of Science and Technology (POSTECH) was started. The purpose of this research project is to develop a special module for induction heating process which is essentially required for metal forming.

A two-dimensional commercial version will be released in early September 2018. The program is already available for research purposes, but this is not so comfortable to use directly.

4.2 For advanced pre- and post-processors

AFDEX's pre- and post-processors have been well received by users. Especially, it has a unique competitiveness in terms of ease of use. In 2017, however, MFRC started to innovate AFDEX's pre- and post-processors together with CodeSE, which is a developer of tools for developing pre- and post-processors and has much experience in developing various engineering GUIs. It is anticipated that from September 2018, when new post-processing programs will be introduced, AFDEX will be able to respond more quickly regarding adding new functions and reflecting user's requirements.

4.3 Global activities

MFRC attended Forge Fair at Cleveland, USA during the month of April and exhibited the latest developments in AFDEX. MFRC will also exhibit in the forthcoming exhibitions organized by the Forging association, USA.

The Altair EATC was held for three days from June 26 to 28, 2017 in the Frankenthal Congress Forum in Germany. Partners and visitors from the PLM (Product Lifecycle Management) industry group, including auto parts manufacturers, participated. MFRC joined the event and presented the latest advancements in AFDEX to an audience comprising of developers, simulation engineers and Altair APA users. During the event, MFRC also had face-to-face meetings with German AFDEX users to gather feedback and provide technical support.

Meanwhile, on Nov 7, 2017, a plan to cooperate with Altair's researchers was discussed in Seoul. Especially, we plan to launch Click2Forge in 2018. Altair introduced the concepts and key features of the recently developed Click2Stamp.

MFRC, in the year 2017, has become an active member and contributor of the Altair Global Support Forum. This is an online platform where some interesting information about metal forming simulation, tips and tricks in AFDEX, etc. are shared periodically. It is another wonderful opportunity for AFDEX and Altair University users to directly interact with our technical support team.

Altair Innovation Intelligence blog (http://innovationintelligence.com/) focuses on the innovative advancements and their applications in simulation technology. Thought leaders, managers and executives from a wide range of simulation companies share their insights in this technical blog. MFRC has contributed 3 articles so far here and will periodically continue to showcase creative applications and simulation results.

As a part of international marketing activities, MFRC held periodic web-meetings for AFDEX users and potential users from USA, Germany, India and Indonesia throughout the year. In addition to discussing user-specific simulations, latest advancements were presented in detail. A webinar titled "Complete Simulation of Forging Process using AFDEX" was held on 09th November for Altair users globally to highlight the latest developments in advanced functions of AFDEX. Industrial examples applying these functions evoked a lot of interest among the attendees.

4.4 Japan

MFRC participated jointly with JSOL in MF-Tokyo, Japan's largest metal forming exhibition held from July 12 to July 15, 2017, and conducted public relations activities.

From October 31st to November 1st, 2017, Dr. Chung, Suk-Hwan attended the JSOL LS-Dyna & JSTAMP Forum 2017 held in Tokyo and presented the recently enhanced functions of the die elastic deformation. This forum, which attracts around 400 people every year, is a meeting of LS-Dyna and JSTAMP users, but AFDEX developers are invited as key speakers every year. This forum has attracted more researchers than usual and evoked a lot of interest in Japanese CAE technology. In this forum, all the software handled by JSOL is displayed along with the presentation of research cases. AFDEX has been gaining a lot of prominence in the recent years in the Japanese market and this was visible during MFRC's participation at this exhibition. It was also confirmed that about 100 members participated in the presentation of the research results leading to further research and interest from Japanese researchers.

JSOL's researchers also attended MFCAE 2017 and presented some typical applications of AFDEX in Japan. They also presented the statistics of AFDEX users in Japan, which showed a steady increase in the number of users.

4.5 China

Prof. ManSoo Joun visited Nanjing University of Technology as a member of the international cooperation team between Nanjing University of Science and Technology and Gyeongsang National University in the middle of December. Additional visit was made to the Nanjing Aeronautical and Aerospace University to discuss cooperative research activities in the field of sheet metal forming and special forming process.

Meanwhile, a meeting with BRIMET was held during this visit to discuss commercialization of a microstructure prediction model developed in China, and a forging company visit was also made.

4.6 India

MFRC will be participating in the International Forming Technology Exhibition (IMTEX) in Bangalore in the last week of January 2018. A two-day workshop titled "Advanced Forging Simulation", organized by DHIO, one of AFDEX agents in India will be held on 30 and 31 January 2018 at Bangalore. Experts from forging die design and failure studies would be delivering key note speeches and the seminar would be presided by Dr. Man Soo Joun.

After the events at Bangalore, visits will be made to Pune where a 2-day seminar will be conducted under cooperation with ARAI (Automotive Research Association of India) and AIFI (Association of Indian Forging Industry). Further cooperative research work with respect to material parameters and related technology would be discussed with faculty of IIT Bombay. The business trip to India will come to an end with a one-day workshop for potential AFDEX users at Delhi.

4.7 Indonesia

From 4th to 9th December 2017, two MFRC researchers represented AFDEX at the Manufacturing Indonesia 2017 Exhibition, additionally with the purpose of training an AFDEX user at their company in Jakarta, Indonesia.

4.8 Mexico

MFRC and Universidad Politecnica del Valle de Mexico (UPVM) signed an agreement to open an AFDEX center in the last quarter of 2017. Through this center, the students of UPVM will get to learn AFDEX and related advanced manufacturing technologies.

Manufactura y Desarrollo Tecnologico (MaDeTEC), a SME in Mexico has become a business partner of AFDEX this year.

4.9 MFCAE 2018

MFCAE 2018 will be held on August 23 and August 24, 2018. The detailed plan is being worked upon and will be finalized soon.

4.10 Enriched AFDEX website

AFDEX website has been steadily enriched and number of visitors is increasing. The major events of the last year can be seen from the website and new applications or functions can also be enjoyed and experienced.

In the last year, we had added a number of new applications to AFDEX website, including 2D complete analysis, 3D complete analysis, 2D structural analysis of assembled die, 3D structural analysis of assembled die, Heat treatment simulation of a Jominy test, Metallurgical identification of material, Multi-scale microstructural evolution, Carburization simulation, Quantification of grain flow, 3D air trapping simulation, Swaging simulation, Warm radial forging simulation, Special remeshing function for ring rolling, 3D process design optimization, Springback analysis, Scroll forging simulation with emphasis on effect of material and die model on predictions, Typical multi-stage cold forging simulation, Ductile and brittle fracture at the end of forging, Sheet metal forming simulation, Plate forging process, Comparisons of AFDEX and other software, etc. Of course, there had been almost 200 other applications.

Sharing one's creative experiences make the world a brighter place. This also helps in gaining wider perspectives which in turn makes us more competitive. Of course, metal forming engineers should be creative to accomplish such advancements because metal forming is in itself very creative. It is certain that, gradually AFDEX website will become a classroom for educating creative metal forming technology.