AFDEX Newsletter
2017 Winter

MFRC
Web: www.afdex.com E-mail: mfrc@afdex.com
Tel: +82-55-854-7529 Fax: +82-55-854-1837

Contents

1. AFDEX_V16

1.1 Release of new version: AFDEX_V16R01

AFDEX_V16R01, published on Jul. 6th, 2016 is the official version verified by software experts throughout the world, while it is also derived from the previous version V16R00 published on Apr. 1st in the same year. It was additionally upgraded on Oct. 1st, and then distributed again. Any users who have the version before Oct. 1st, 2016, are kindly requested to update the program with newest version. In the meantime, the publication of V17R00 is targeted for Apr. 1st, 2017, whose main functions are described in detail in the next section. New important functions and improvements in AFDEX_V16 together with those in AFDEX_V17 are listed in Table 1.1.

Table 1.1 New functions and enhancements

Item	Type	Description
Enhancements	2D	- An option for limit load changed - An enhanced local mesh density - A mesh regeneration option included - Convergence improved in the plate forging process - Improved editing function for allowable volume - Improvement of realistic grip handling in the drawing process - Die deformation due to shrink fit possible - Improved setting of die boundary conditions - Stage by stage analysis possible
	3D	- An option for limit load changed - Die deformation due to shrink fit possible - Blow no. changed to stage no. in hammer forging process - Improved velocity enforcement timing - Improvement of realistic grip handling in roll forging process - Improved setting of die boundary conditions - Stage by stage analysis possible
New functions	2D	- Elastic die deformation considered - Die deformation due to shrink fit and elastic deformation possible - Iterative analysis between specific steps possible (1.2.6) - Elastic press deformation considered (1.2.7) - Boolean operation allowable (1.2.8) - An optimized process parameter possible with Altair HyperStudy - Heat transfer analysis between assembled die (2.2.2) - Structural analysis of assembled die possible (2.2.2)
	3D	- Elastic die deformation considered - Die deformation due to shrink fit and elastic deformation possible - Repeated analysis between specific steps possible (1.2.6) - Elastic press deformation considered (1.2.7) - Heat transfer analysis between assembled die (2.2.2) - Structural analysis of assembled die possible (2.2.2)

1.2 Newly embedded functions in AFDEX_V16R01

1.2.1 An elastoplastic finite element analysis with shrink fit and an elastic die deformation

Figure 1.1 shows the cold forging analysis results of a multi-part or assembled die structural analysis together with elastoplastic finite element analysis of the material which were obtained using a new function of V17R01. Figure 1.2 depicts the elastoplastic analysis results in the die for an axisymmetric cold forging process, shown noticeably in terms of induced displacements, stresses together with the shrink-fit rings.

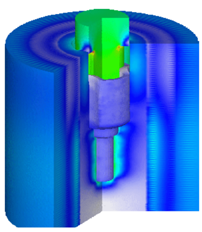
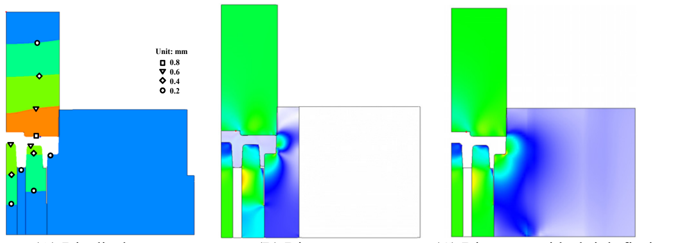


Fig 1.1 An elastoplastic finite element analysis with assembled die structural analysis



(A) Die displacement (B) Die stress (C) Die stress with shrink-fit rings

Fig. 1.2 An elastoplastic finite element analysis of an axis-symmetric cold forging process considering elastic deformation of die

1.2.2 A rigid-plastic finite element analysis with an elastic die deformation

Figure 1.3 (A) compares the metal flow lines between the rigid and elastic die. A piping defect at the central region is more distinguishable in the elastic die case. This phenomenon eloquently illustrates the reason why the rigid die model may not properly predict the real forming load even if it gives us reliable metal flow lines or grain flows. The rigid-viscoplastic finite element predictions for an axisymmetric hot forging process can be observed in Figure 1.3 (B) in which the forging load in the model of an elastic die is about 30% less than that of a rigid die case.

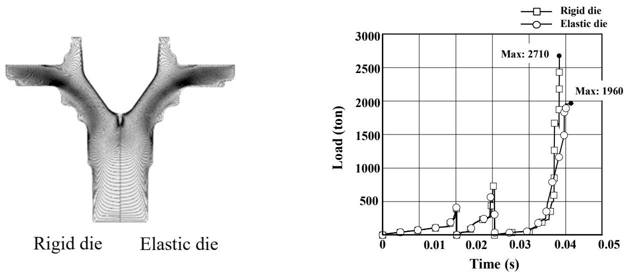


Fig. 1.3 (A) Metal flow lines comparison (B) A rigid-plastic finite element analysis with an elastic die deformation in an axisymmetric hot forging process

Figure 1.4 represents the finite element predictions of a crank shaft forging process, obtained with emphasis on die elastic deformation during forming simulation. It should be noted that this die elastic deformation was a coupled analysis with the material undergoing plastic deformation.

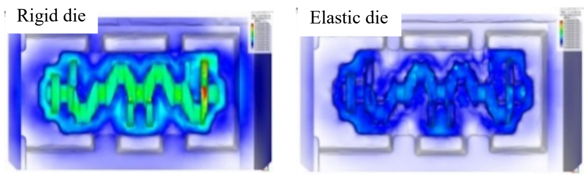
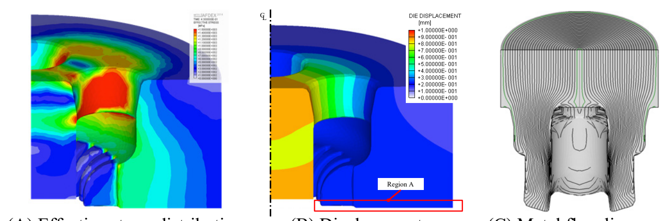


Fig 1.4. Residual stress in each die model

Like observed in the 2D analysis, the forming loads start increasing rapidly as soon as the material starts to fill the empty space. Meanwhile, if the elastic deformation of die is considered, the sharp rise of forming load also induces an elastic deformation in the die, ultimately retarding the increase of the required forming load by a large amount. The analysis predicts maximum displacement of 0.13 mm in the die, while the overall metal flow lines are quite similar to the results predicted by the rigid die model.

1.2.3 A Pothole extrusion process with an elastic die deformation

The effective stress distribution, metal flow lines, and displacements in the die during the pothole extrusion process are depicted in Figure 1.5. The elastically deformed die was emphasized.



(A) Effective stress distribution (B) Displacement (C) Metal flow lines

Fig. 1.5 Finite element predictions of a pothole extrusion process with emphasis on die elastic deformation coupled with material plastic deformation

1.2.4 Detailed structural analysis of 2D axis-symmetric dies

Figure 1.6 shows an example of structural analysis for a pre-stressed axis-symmetric die. Till the previous version (V16), there have been constraints upon the mesh configuration to improve the solution accuracy when analyzing multi-body elastic problems. And it might well have caused some application difficulties so that only the most professional users performed the relevant simulation in a limited range. The version V17 is now equipped with an optimized contact algorithm, nicely eliminating those constraints on the meshes which is readily available to any kind of users. In AFDEX_V16, this function has only been applicable to the die analysis module. However, from the version V17, the structural analysis and heat transfer between parts even in the assembled die cases (composed of less than 20 parts at a stage) are also possible.

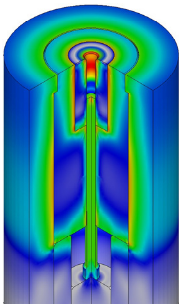


Fig. 1.6 An exemplary structural analysis of an assembled axis-symmetric die

1.2.5 Detailed structural analysis of 3D dies

Figure 1.7 shows the simulation result for 3D die structural analysis. When using the option for a shrink ring in the existing version, some rare occasions were reported in which no rings are generated. And the related routines have now been enhanced to avoid such undesirable cases. As seen in 2D case this function is also available from the version of V17 for the structural analysis and heat transfer between parts in the assembled die cases (See Figure 1.1).

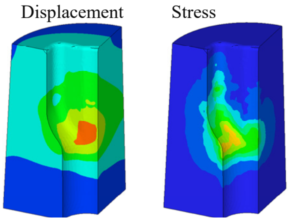


Fig. 1.7 Die structural analysis results from die analysis module

1.2.6 An iterative analysis between specific steps

Figure 1.8 shows an example of drawing process, obtained using the iterative analysis scheme to trace the temperature change especially in the plug and dies in pipe drawing. The function allows iterative analysis of the same initial material with updated die with elevated temperature in the specified time interval. Of course, it can be applied to predict the temperature change of forging dies during forging, roll temperature in strip rolling, etc.

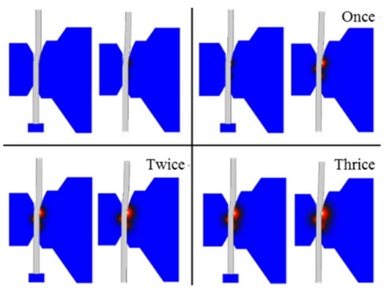


Fig. 1.8 An iterative analysis of the pipe drawing process

1.2.7 Function considering elastic deformation of press

An analysis of an elastic deformation induced in the press is sometimes vital to the precise expectation of the forming loads. The forming load at the final stroke of closed forging process is abnormally increased on the common assumption of rigid body press. The remedy of considering elastic deformation of the press structure at the same time with die elastic deformation plays a meaningful role in solving such kind of problems.

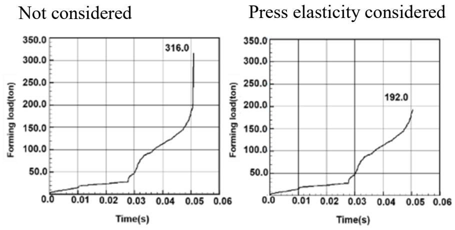


Fig. 1.9 Forming loads with an elastic press deformation

1.2.8 An analysis with material cutting process involved

New functions are embedded in order to analyze the cases in which the material is partially removed during simulation. Based on the function, the process analyses can be continuously performed, for example, an automatic multi-stage forging process can be simulated with drawn initial material as shown in Figure 1.10. This function may be used to predict approximately the change of residual stress after material removal.

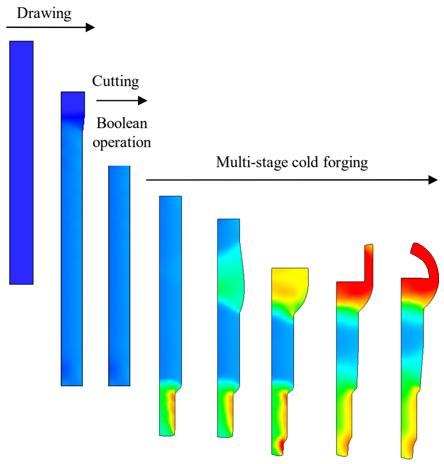


Fig. 1.10 An exemplary analysis for an automatic multi-stage cold forging process based on the material removal function

1.2.9 Optimization function coupled with HyperStudy of Altair

The function of optimizing pivotal parameters in the forging process is now available, as AFDEX is now coupled with Altair's HyperStudy. Any user who is already exposed to the AFDEX input data structure can easily access the function of process design optimization.

a) Followings are basic information about the forging process for the transmission gear blank to be optimized:
- Stage: 2-stage hot forging
- Material: SCr420H
- Press: 2500 ton, mechanical
- Friction: μ = 0.2

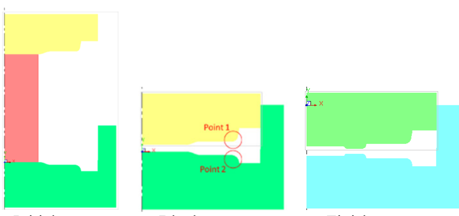


Fig. 1.11 Schematic diagrams for the forging process

b) The problem definition and conditions are as follows:
- Design variable: radii of point 1 and 2
- Point 1: 2~13 mm (0.5 mm incremental), Initial value: 6.0 mm
- Point 2: 2~8.5 mm (0.5 mm incremental), Initial value: 4.0 mm
- Constraints: forming load in the blocker process < 1600 ton
- Objective function: Maximum load of finisher process
- Algorithm: GRSM (Global Response Surface Method)
- Maximum repetition number of analysis: 100 times
- Initial sample points: 4 points

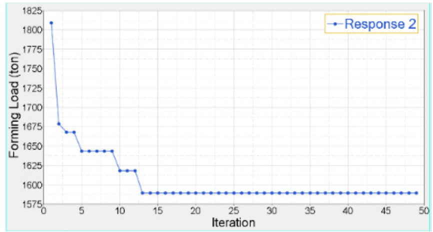


Fig. 1.12 Forming loads versus iteration

c) Optimization results are summarized as follows:
- Forming loads with initial values at Point 1 & Point 2
- Blocker and finisher: 1800 and 2030 tons, respectively
- Optimized design variables and the resulting output
- Radii of point 1 and point 2: 11 and 7.5 mm, respectively
- Forming load in the blocker process: 1595 ton
- Forming load in the finisher process: 1589 ton

1.3 Research publications

Last year AFDEX development team had published totally 23 application papers, which mainly covered those precision forging analysis technologies based on the new functions embedded in AFDEX_V16, especially with elastic deformation in the dies and presses duly considered. http://www.afdex.com/

Table 1.2. List of papers written by AFDEX development team

2016 Spring conference of Korean Society for Technology of Plasticity	
1	Consideration on accuracy in forging simulation
2	Elastoplastic finite element analysis of axis-symmetric cold forging process with an elastic die deformation
3	Rigid-viscoplastic finite element analysis of axis-symmetric hot forging process with an elastic die deformation
4	Elastoplastic finite element analysis of a bevel gear in consideration of an elastic die deformation
5	Rigid-plastic finite element analysis of hot forging process in a crankshaft with an elastic die deformation
6	An analytic review on the AFDEX spring-back capability
7	Finite element modeling of a hot aluminum roll forging process with emphasis on the grip role and its application
8	Elastoplastic finite element modeling of an ultrasonic surface rolling process under the plane strain condition
9	Analysis of the fixed scroll die forging process in consideration of the elastic die deformation
10	Finite element prediction of die temperature change in the long material drawing
11	Finite element analysis of a porthole extrusion process with an elastic die deformation
12	Optimization of initial blank shape in an elliptic multi-stage deep drawing for formability improvement
2016 Autumn conference of Korean Society for Technology of Plasticity	
13	Elastic deformation of tools by AFDEX elasto-plastic finite element analysis
14	Experimental verification of the finite element predictions of the side bolt roll forging process
15	A study on the fracture of shear die in cold piercing after hot press forming
16	Spring-back analysis of a precision forging process considering temperature effect
17	Numerical and experimental study on die deformation in hot forging by rigid-thermoviscoplastic finite element method
18	Analysis of a forging process considering elastic deformation of press
19	Combined coupled analysis of a hot forging process with the die deformation owing to mechanical and thermal load
20	Material and die deformations coupled analysis of a precision forging process
21	Precision forging simulation using a mesh density optimization scheme
22	Analysis of billet deformation during double shear twist extrusion process
23	A study on optimization of die shape parameters of a forging process using AFDEX and HyperStudy

2. New functions in AFDEX_V17

2.1 Overview

The beta version of AFDEX_V17 will be released on Apr. 1st, 2017 and its formal version is also expected to be released on Aug. 1st, 2017, while most upgraded one is to be in the market by Oct. 1st, 2017 after some due revisions. In this series of newer versions, AFDEX will be armored by such functions of the die structure analysis with fortified post-processor module and most enhanced functions for metallurgical predictions (heat treatment and micro-structure) will be added for the first time.

2.2 Introduction of new functions

2.2.1 Mechanically synthesizable functions

The original version of AFDEX_V16R01 was not able to simultaneously simulate the coupled process of material under thermal deformation and elastoplastic deformation, together with the die experiencing the shrink fit and heat transfer while in an elastic deformation. The newly revised release, however, can simulate such a coupled process, as die structural analysis can be made in total consideration of thermal, mechanical and shrink fit loads.

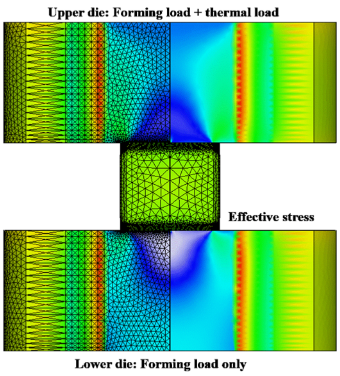
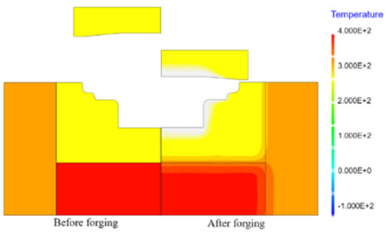


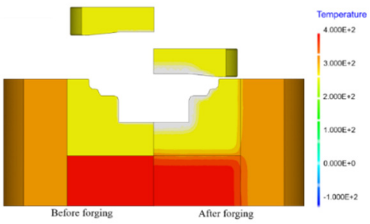
Fig 2.1 An integrated analysis example of upsetting process

2.2.2 Heat transfer function of assembled die

From AFDEX_V17, an assembled die can be analyzed by heat transfer function. Figure 2.2 shows simulation results obtained considering heat transfer between dies. Meanwhile, this heat transfer function can be used with structural analysis function at the same time.



(A) 2D

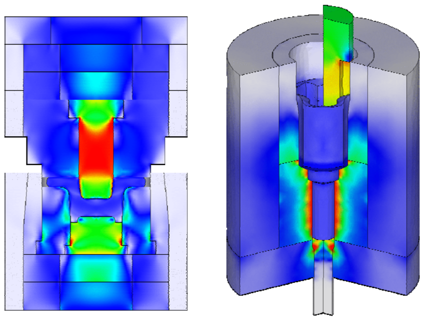


(B) 3D

Fig. 2.2 Heat transfer analysis between die parts

2.2.3 Structural analysis of assembled die

In AFDEX_V16, structural analysis of assembled die is impossible during forming analysis. But, from AFDEX_V17, assembled die can be simultaneously simulated with forming simulation. Both A and B are the simulation results of the 2D and 3D examples, respectively.



(A) 2D Axis symmetric (B) 3D

Fig. 2.3 Die structural analysis of assembled die

2.2.4 Predicting microstructure evolution

A deeper understanding of metallurgical phenomenon is the most important pre-requisite in properly predicting metallurgical deformation 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.

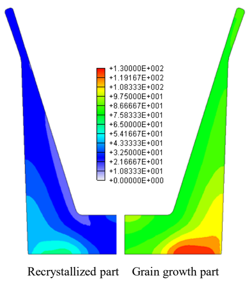


Fig. 2.4 A micro structure prediction of AA6060 material

Considering various metallurgical phenomena like static recrystallization (SRX), dynamic recrystallization (DRX) and grain growth, which are influenced by overall heat treatment and manufacturing process, those analytic methods hired by AFDEX enable the prediction of grain size growth during the plastic process involved. Figure 2.4 shows an exemplary prediction result of a typical microstructure.

2.2.5 A function for heat treatment process

This function is to predict mechanical and thermal deformation occurring in the usual heat treatment process, which will be based on the diffusive transformation model (Jounson-Mehl-Avrami-Kohnohorov) and non-diffusive one (Koistien-Marburger) as well. Figure 2.5 shows such a simulation result obtained by a typical heat treatment process.

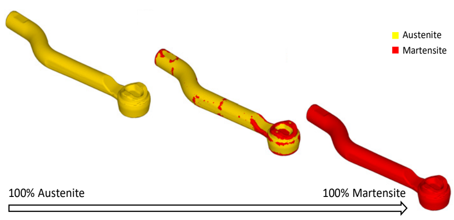


Fig. 2.5 A typical 3D Heat treatment process

3. Recent activities

3.1 MFCAE 2016

MFCAE 2016 was held in Jeju Island, Korea on August 18th to 19th, 2016, covering a wide range of innovative metal forging technologies with 19 oral presentations and 62 poster presentations. The topics were from various fields including industrial applications, educational use cases, academic research works, and a detailed introduction to new and enhanced functions embedded in the latest AFDEX.

Participants were especially encouraged to prepare much more poster presentations to cover the difficulties stemming from language problems, limited time and communicative inefficiency in each oral presentation. Meanwhile, new ingredients such as dinner of standing buffet type and bus tour around Jeju's scenic sites were pleasing aspects of the events, for, they enabled engineers and researchers to closely interact and share each other's experience and pleasant memories.

Fig.3.1 MFCAE 2016

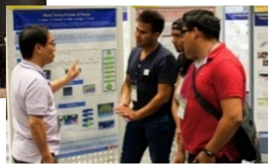


Fig 3.2 Poster presentation and Q&A session

3.2 GISPAM 2016 and GKS-ASEAN 2016

Last summer, MFRC conducted an international education program, GISPAM 2016 for five weeks stretching from July 18th to Aug. 20th. GISPAM stands for GNU International Summer Program of AFDEX and other engineering software for the state of Mexico, and corresponds to a short term educational course fully sponsored by the state of Mexico, in which each year 20 Mexican university students are involved in the subjects of mechanics, CAD, and four engineering software namely, AFDEX, Z-CAST, MAPS-3D and RecurDyn. GISPAM originally started from 2014 for three weeks of time span, grew to 5 weeks in the 2nd year and now it is steadily evolving as a well-established model of international academic cooperation, which is reflected from the fact that those 20 students showed their program satisfaction index of 98 out of 100 in the program evaluation survey after the course.

Meanwhile, a program of GKS-ASEAN quite analogous to GISPAM was also processed for 6 weeks nearly at the same seasonal time, in which 24 qualified students from 7 ASEAN countries participated with an academic background of mechanical engineering in their university. The main structure of GKS-ASEAN was very similar with GISPAM, so that 24 ASEAN students, 20 GISPAM students and 24 GNU students enrolled in the summer session could all enjoy the opportunity of mingling together in the same class, additionally enabling energetic and passionate youngsters to become close friends and utilize their precious time on international social exchange.

Fig. 3.3 GISPAM 2016

Fig. 3.4 GKS-ASEAN 2016

Coupled with ASEAN program was the course for GNU students titled "An introductory Finite Element Method." Totally more than 30 students reportedly attended the course, while they unanimously agreed to experience real advancement in each one's major as well as in the English language through a course" English Speaking and Listening."

3.3 AFDEX developers' meeting 2017

AFDEX developers' meeting was recently held at GNU, Jinju on Jan. 6, 2017, which is a regular annual event with 22 developers attending this time. Relevant movements in the previous year and future work were discussed in detail. Overall development outputs were reported, and then followed by each researchers' solver discussion, also together with entangled problems and productive suggestions put on the table.

Fig. 3.5 The 1st regular 2017 developers' meeting

4. Domestic / International cooperation

4.1 Domestic cooperation

4.1.1 Altair Technology Conference 2016 Korea

On Sep. 23rd, 2016 Mr. Min-Cheol Kim, one of team managers at MFRC, attended the event of 2016 ATCx held by Altair Korea at Conrad Seoul Hotel, whose slogan was "Key to Smart Manufacturing, CAE and subtitled "Manufacturing in the future seen by CAE". (Link: http://blog.altair.co.kr/38926)

During the RADIOSS session Mr. Kim presented research results titled 'An optimization study on geometric parameters for forging dies based on AFDEX and HyperStudy' together with AFDEX introduction. See the details in section 1.2.9.

4.2 International activities

4.2.1 Overseas research collaboration

Last year, MFRC and Purdue University in the United States agreed on the MFRC's sponsorship program for an applicative research on microstructure evolution and its prediction of resulting mechanical properties, to be performed by Purdue University for three years starting from 2016. Purdue has already accumulated basic research outputs, as it fully secures relevant research information and papers on metallurgical characteristics based on the previous material focused experience during the manufacturing process. MFRC is going to fully fund the research and the research output would supposedly be commercialized for market applications by MFRC.

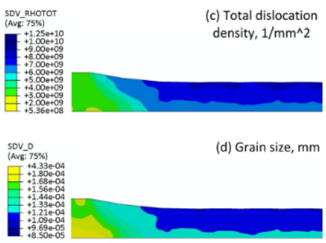


Fig. 4.1 Pre-study results by Purdue University

By strengthening the cooperative development research with world-class universities, MFRC looks forward to accelerating its development pace of AFDEX's cutting-edge modules and utilizing the chances to expand our network with top-class research community and researchers. It is notable that Purdue has already been using AFDEX at the department of Mechanical engineering from the year of 2011 for educational purpose.
https://engineering.purdue.edu/ME363/

4.2.2 MFRC in the Altair rollout events held in China

In the Altair rollout events held from April through May nationwide in China, which comprised the major cities of Shanghai, Changsha, Beijing, Xian, and Shenzhen.

Fig. 4.2 MFRC in China for Altair rollout events

MFRC and its Chinese business partner BRIMET had joined together in broadly presenting AFDEX in the land of the biggest forging market. Over 450 people from relevant business sectors attended the events and shared the precious technical opportunity.

4.2.3 New agent companies in India and Vietnam (KRATOS, UPVIET)

In late April, 2016 MFRC made business contracts with Kratos Eng. from India and UPVIET Co. from Vietnam, respectively, so that they may fully support users in each country technically. Kratos Eng. is the company which successfully introduced MOLDEX 3D to Indian market dealing with MSC software, Core Technologies, Delcam and PTC etc., while UPVIET has an expertise in MAGMA, the casting software, together with Hyperworks and Mento graphics E-CAD as well. MFRC has another agency in India, DHIO.

4.2.4 Educational events held in China

An AFDEX users' meeting was also held on April 19th at Shanghai Holiday Inn Hotel, where more than 50 researchers and engineers attended as seen in the picture 4.3. Prior to the meeting, the AFDEX delegates including Dr. M.-S. Joun visited BRIMET to check the status of on-going cooperative research topics for microstructure prediction, additionally hosting a seminar in Yanshan University in Qinhuangdao city, which soon led to a mutual R&D collaboration agreement in different processes like rolling etc. MFRC also visited several companies in the region from the industrial sectors of forging, sheet metal forming and forging equipment, which were kindly introduced by BRIMET.

Fig. 4.3 AFDEX user meeting held in Shanghai, China

4.2.5 Cooperative talks with JSOL

On March 26th, the two companies, MFRC and JSOL (AFDEX's strategic partner in Japan) met in Seoul to hold a policy review session for user supportive issues in the market. They had ardently discussed to produce the most reasonable ways of AFDEX version management, resulting in the agreement of sharing JSOL's precedent experience in the relevant matters so that more systematic customer support activities might be tangible in near future.

4.2.6 Workshop in Iran

Mr. M. Irani, professor at Iran University of Science and Technology, who is currently enrolled as Ph.D. candidate at GNU, had recently conducted a two-day training session for forging simulation technology titled "Learn how to use AFDEX for metal forming simulation" where 18 Iranian researchers, engineers and graduate students in the region reportedly participated.

Fig. 4.4 A forging simulation class in Iran using the AFDEX

4.2.7 AFDEX workshop and seminar in India

An AFDEX workshop was held for Indian engineers at Pune, India on July 20th, where in the first part, an AFDEX experience opportunity for the engineers were offered, then followed by a technical seminar given by Mr. Y.G. Choi from Samwoo Co. and Prof. M.S. Joun from MFRC.

Fig. 4.5 An AFDEX workshop held in India

4.2.8 Attendance at LS-DYNA & JSTAMP Forum 2016

Prof. M.S. Joun additionally attended the JSOL LS-DYNA & JSTAMP Forum for two days, Nov. 8th to 9th in Nagoya, Japan, delivering a presentation focused on the most recently fortified simulation technology of bulk metal forming process together with emphasis on die elastic deformation.

Meanwhile there were also technical tour events made by MFRC's engineers to Japanese major user companies including Asahi Sunac (Nagoya) and Gubota (Hiroshima).

4.3 Global exhibitions

MFRC had presented its software achievements to several renowned domestic and international exhibitions all along the year of 2016, while it is expected to be present in some important 2017 display events including Hannover Messe in Germany. Each customer is encouraged to visit AFDEX booth in case you may find such nice chances to be at exhibitions below.

Table 4.1 Exhibitions attended - 2016

No.	Exhibition	Date
1	Hannover Messe	Apr. 25 ~ 29
2	SIMTOS 2016	May 20 ~ 23
3	Korea 2016 Metal Week	Oct.19 ~ 22
4	Smart Biz Expo 2016	Oct. 26 ~ 29
5	Asia Forge Meeting	Nov.07 ~ 08

Table 4.2 Exhibitions planned - 2017

No.	Exhibition	Date
1	Automotive Weight Reduction Tech Fair	Feb. 15 ~ 17
2	Forge Fair, Ohio, USA	Apr. 4 ~ 6
3	Hannover Messe	Apr. 24 ~ 28
4	ATC UK	May
5	ATC Europe	Jun. 26 ~ 28
6	MF Tokyo	Jul. 12 ~ 15
7	Korea 2017 Metal Week	Oct. 24 ~ 27

5. Public notice

5.1 MFCAE 2017 users conference

MFCAE 2017 will be held in the city of Changwon, Korea for two days spanning from Aug. 17th to 18th, which is the formal name of the AFDEX users conference. The conference is supposed to introduce new functions embedded in the new version of AFDEX whose details are to be explained separately by way of posters to the interested participants. Orally presented subjects are principally followed by poster presentations again, through which vigorous technology interchanges are widely anticipated.

Note that we are putting no restrictive barriers on the presentation language even though the conference is an international event. Speakers may give presentations either in their mother tongue or in English when preferred, while translation services are available during the presentation when needed. For timetable and conference details you are encouraged to visit our website www.afdex.com. The schedule of MFCAE 2017 is presented in Table 5.1.

Changwon is the most industrialized city in Korea, located in the southern part and has many heavy machinery industries. Busan airport is the nearest airport accessible to Changwon. The link to the venue of MFCAE and its directions are given below. https://pullman.ambatelen.com

Table 5.1 MFCAE 2017 schedule

Date	Place	Contents
Aug. 17 (Th) ~ 18 (Fr)	Pullman Ambassador	Application

Fig. 5.1 Hotel Pullman Ambassador and directions

5.2 Consortium of fasteners and plate forging advancement

MFRC is determined to fully support the Consortium of Fasteners and Plate Forging Advancement led by Prof. Seok-Mu Hong at Kongju National University. It is supposed to recruit students who want to enter the relevant industrial field, giving them specialized education together with educational scholarship secured so that qualified and professional working forces are well fed to the relevant companies in the consortium. Those companies participating in the Consortium are required to pay the specified annual membership fee and provide students with field-oriented education programs. Any interested companies will be answered right away with the information below.

MFRC is also very positively considering a role of some financial contribution together with residential manpower at the Consortium. They are duly supposed to provide students with educational sessions, while companies in the region will be additionally given the chances of face-to-face technical support.

- E-mail: smhong@kongju.ac.kr