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Coordinator: Manufacturing Engineering Centre, Cardiff University

Table of Contents

1. Project information

Project title	Digitally Adjustable Tooling for manufacturing of Aircraft panels using multi-point FORMing methodology
Project title	DATAFORM
Programme	The Sixth Framework Programme (FP6)
Thematic priority	Aeronautics and Space
Call identifier	FP6-2005-AERO-1
Research areas	AERO-1.1 Strengthening competitiveness Specific Targeted Research Project
Instrument	Specific Targeted Research Project (STREP)
Contract number	AST-CT-2006-030877
Start date	1 October 2006
End date	31 December 2009
Duration	36 months
Total cost	€3,725,230
EC funding	€ 2,462,675
Website	http://www.dataform.cf.ac.uk

2. Consortium

CU(MEC)	Manufacturing Engineering Centre (MEC), Cardiff University, UK (Coordinator) http://www.mec.cf.ac.uk/
OENG	Open Engineering SA, Belgium http://www.mec.open-engineering.com/
CENAERO	Centre de Recherche en Aéronautique ASBL , Belgium http://www.cenaero.be/
JLU	Dieless Forming Technology Development Centre, JiLin University, China http://www.jlu.edu.cn/
KI	Kayser Italia, Italy http://www.kayser.it/
SENER	Sener Ingenieria y Sistemas S.A., Spain http://www.sener.es/

3. Project main objectives

The project "**Digitally Adjustable Tooling for manufacturing of Aircraft panels using multi-point FORMing methodology (DATAFORM)**"focuses on researching and developing digitally adjustable multi-point tooling for the manufacture of aircraft panels. DATAFORM will play a key role in realising the full potential of flexible tooling by combining multi-point forming technology and robotic control technology.

The main objective of DATAFORM is the development and application of digitally adjustable tooling using multi-point forming methodology for manufacturing 3D panels of fuselage and wing cover in aviation. The DATAFORM project directly addresses the Research Area of Aeronautics and Space; "Manufacturing" and "Integrated design and product development" (FP6-2005-Aero-1.1, Strengthening competitiveness Specific Targeted Research Project).

In particular, DATAFORM will enable **rapid, flexible and cost-effective forming of skin panels in aircrafts with digitally adjustable multi-point tooling** with the following industrial and scientific breakthrough objectives of the project are :

(1) Fundamental exploration of digitally adjustable tooling using multi-point forming methodology for forming and fabrication. This will lead to the realisation of rapid dieless forming of skin panels and to the accurate jigless fabrication of panel structures in aviation.

(2) Solution of the key technological problems of adjustable multi-point tooling. This will lead to the development of an adjustable multi-point tooling compositing punch matrices to replace the solid dies or hard tooling.

(3) Building of integrated CAD/CAE/CAT software and robotic close-loop control devices for the modular system. This will lead to an innovative analysis and optimisation process, the automatic control of punches and quick adaptation to component design or engineering changes.

(4) Development and implementation of digitally adjustable multi-point tooling and techniques in the manufacture of aircraft products. This will lead to a reduction in tooling costs of 60%, cut set-up time by up to 50% and decrease traditional hard tooling lead time. It will also eliminate the need for tooling storage and increase tooling utilization significantly.

It is the aim of DATAFORM to empower digitally adjustable tooling technology with a clear focus on its industrial use for aeronautics and to drive the rapid development of flexible tooling in manufacturing, leading to new processes and immediate industrial exploitation. The main advantageous features of DATAFORM are rapid, universal, and cost-effective with high flexibility, compared with present hard tooling for panel forming and panel fabrication.

4. Objectives for the reporting period

- To fabricate digitally adjustable multi-point tooling prototypes with appropriate CAD/CAM/CAE software platform and robotic control units for die-less forming and jig-less positioning processes;
- To integrate and validate the developed HW/SW components into systems ready for different applications;
- To explore potential market on manufacturing 3D panels using three developed digitally adjustable multi-point tooling prototypes;
- To disseminate widely innovation information on the DATAFORM project results and achievements through effective multimedia;
- To demonstrate the digitally adjustable multi-point tooling technologies with selected applications through large international events;
- To promote and exploit the DATAFORM project results by cooperation with potential commercial end-users in the world.

5. Work performed and results achieved

The project is broken down into six workpackages (**WP**s) that will lead to the completion of the ultimate goal of the project.

Workpackage 1	Technology Assessment and Targets Specification
Workpackage 2	Research of Adjustable Multi-Point Tooling Technology
Workpackage 3	Development of Digitally Adjustable Multi-Point Tooling
Workpackage 4	Integration and Validation
Workpackage 5	Dissemination and Exploitation
Workpackage 6	Project Management

WP1: **Technology Assessment and Targets Specification**
This work package has been finished in first year and not within the reporting period.

WP2: **Research of Adjustable Multi-Point Tooling Technology**
WP2 aims to study the fundamentals of MPF methodology and explore the capabilities of flexible fabrication tooling technology for aircraft panels. A theoretical analysis on the mechanism of MPF will be carried out for dieless forming applications. WP2 will also study in detail the use of the adjustable multi-point tooling technology for the procedures of joining, measurement or assembly of aircraft panels, in particular on procedures for surface positioning and non-contact measurement.

WP3: Development of Digitally Adjustable Multi-Point Tooling
The primary objective of WP3 is to build a novel and efficient digitally adjustable multi-point tooling system based on the principle of MPF and to develop automatic

robotic control techniques for a flexible fabrication tooling. WP3 will start by studying the requirements in WP1 and the planned applications in WP4, and analysing potential bottle necks and risks. Then it will design appropriate tooling prototypes according to the specification of architecture. Two prototypes of dieless stretch forming tooling and jigless positioning tooling with punch matrices will be developed. A CAD/CAE/CAM/CAT software platform, will also be constructed to deal with the data exchange interface, different materials simulation, and fabrication process control.

WP4: Integration and Validation

WP4 aims to integrate the developed hardware and software components into a DATAFORM tooling system ready for validation and its full functions, and to test and optimise the developed digitally adjustable multi-point tooling, and validate the flexible tooling with different materials for different applications.

WP5: Dissemination and Exploitation

WP5 focuses on the dissemination and exploitation of the R&D results of the project. The demonstration will be implemented through the following activities: public events/workshops and publications including patents, journal & conference papers, reports and the media. Each partner will have at least one publication on average each year. In order to disseminate the DATAFORM project, communication tools will be set up by CU(MEC) in collaboration with other partners including a website. To enable better exploitation of the result, during the first year of the project, an Industrial Advisory Board from potential end users/European tool manufacturers will be set up to ensure the commercial relevance of any solution developed and to provide additional commercialisation routes for the DATAFORM technology.

WP6: Project Management

WP6 concerns all the management aspects of the project and monitoring of progress towards the ultimate objectives, identifying shortcomings and recommending remedial action where necessary. The coordinator will oversee action plans and monitor their timely execution, within the given resources. The consortium members will meet every six months to report project progress. The Steering Committee, Executive Board and Workpackage Groups will meet at the same time.

6. Expected end results

There are four main expected end results:

- Fabrication of three DATAFORM tooling prototypes (*i.e. Multi-point stretch-forming tooling machine, multi-point Press-forming tooling machine and multi-point positioning*

tooling);

- Integration of three DATAFORM tooling prototypes with control unit and CAD/CAM/CAE software;
- Testing of dieless forming of Stretching / Pressing and jigless Positioning.
- Dissemination of DATAFORM project results.

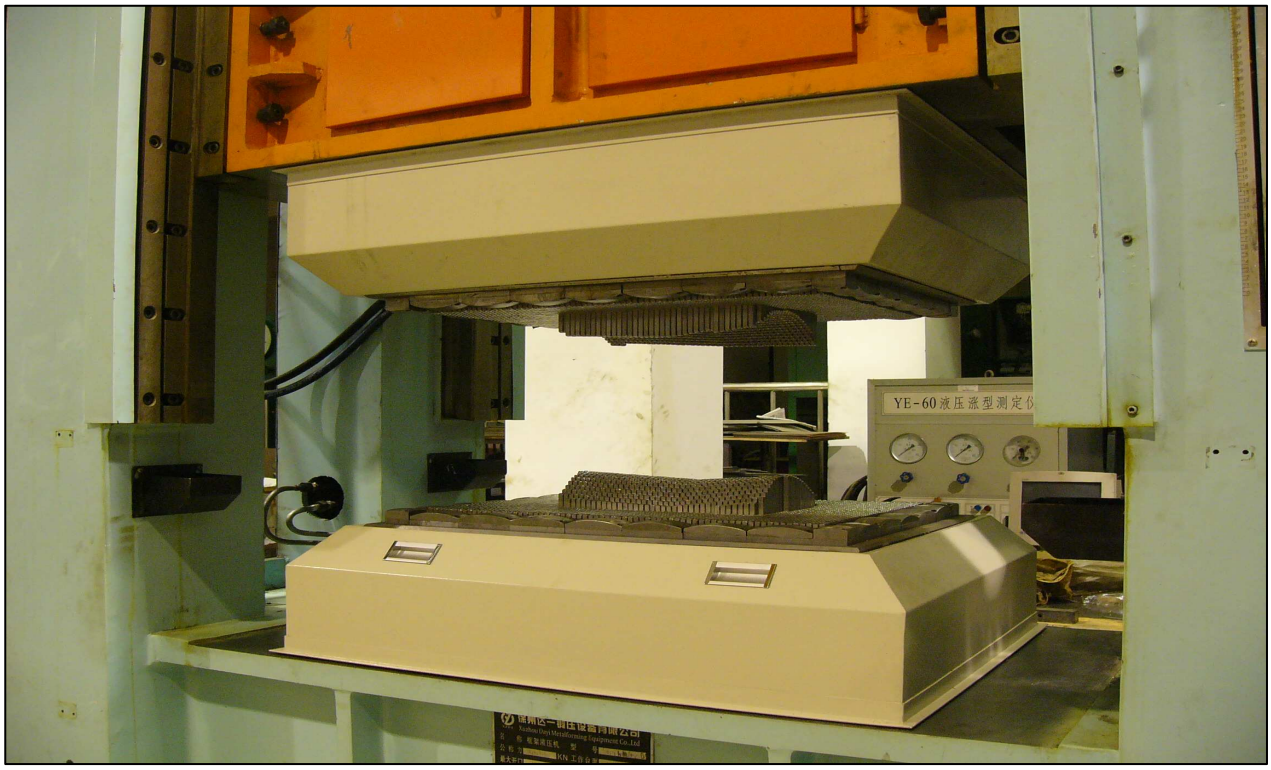

Fig. 1 Figure 4 MPPF tooling and hydraulic press

Fig. 2 MPSF tooling and new stretch machine built by JLU

Figure 3 Integrated computer control units with CAD/CAM software

Figure 4 Integrated MPP tooling with computer control unit

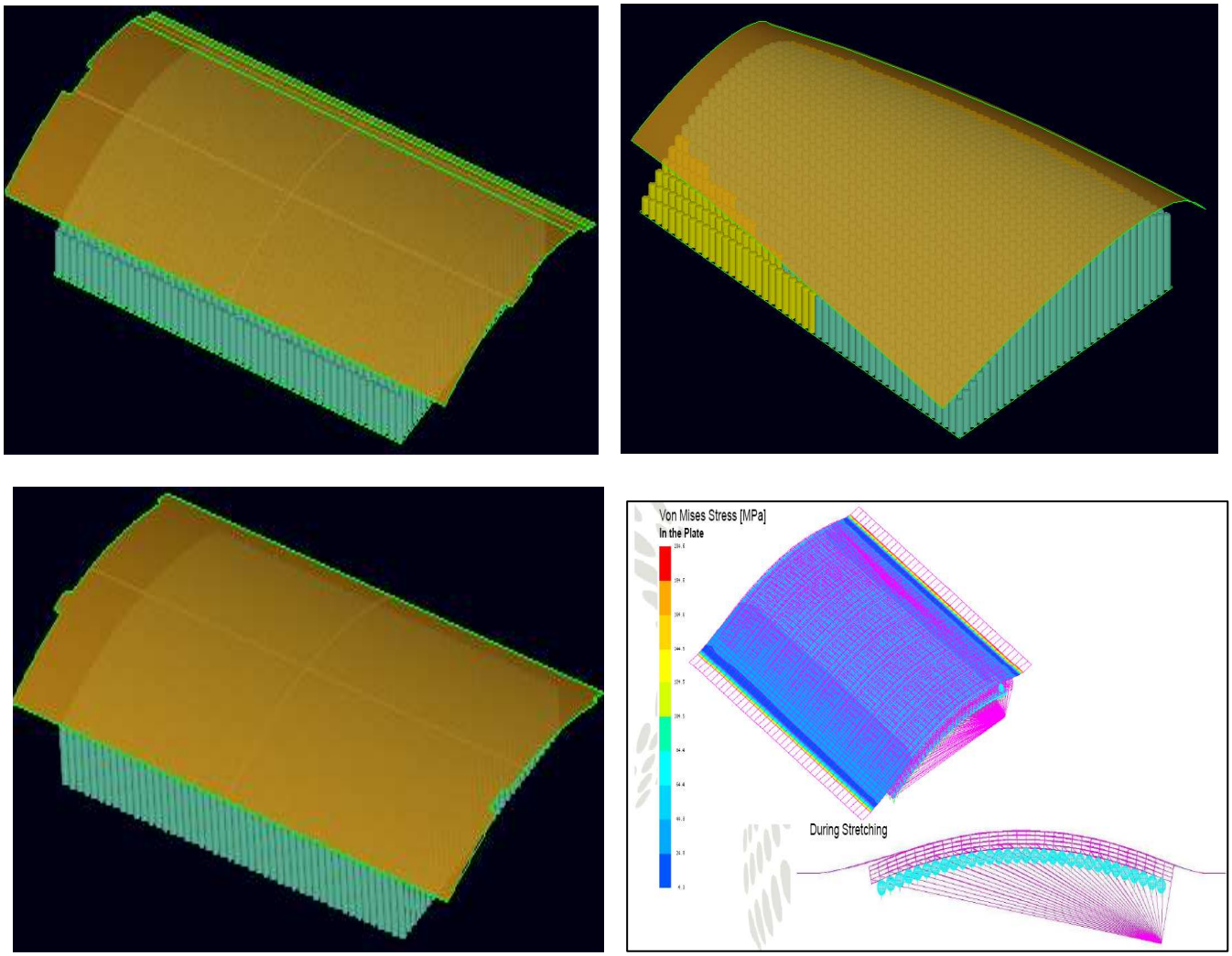

Fig. 5 Calculating results of CAD/CAE for Multi-Point Stretch Forming process

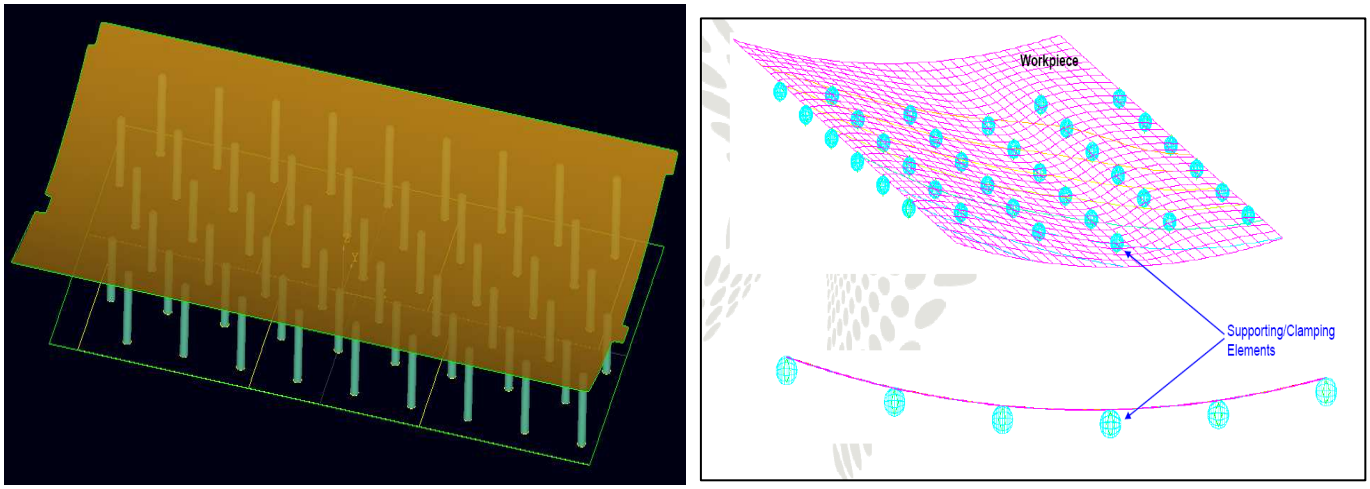

Fig. 6 Calculating results of CAD/CAE for Multi-Point Positioning process

Annex – Plan for using and disseminating the knowledge

A. Exploitable knowledge and its use

Overview table

Exploitable Knowledge (description)	**Exploitable product(s) or measure(s)**	**Sector(s) of application**	**Timetable for commercial use**	**Patents or other IPR protection**	**Owner & Other Partner(s) involved**
Dieless Multi-Point Stretch Forming technologies	Sheet metal forming technologies	Panel forming and tooling manufacturing industry	2009	Licensing	JLU OENG CENAERO SENER KI CU(MEC)
Dieless Multi-Point Press Forming technologies	Sheet metal forming technologies	Panel forming and tooling manufacturing industry	2010	Licensing	JLU OENG SENER CU(MEC) KI CENAERO
Jigless Multi-Point positioning technologies	Panel assembly technologies	Panel assembly and tooling manufacturing industry	2010	Licensing	CU(MEC) KI OENG SENER JLU CENAERO

A1: Dieless Multi-Point Stretch Forming Technologies (JLU, OENG, CENAERO, SENER, KI and CU(MEC))

Multi-point press forming technologies relates to methods, techniques, mechanical design and CAD/CAE software for die-less forming complex aircraft panels using two sets of adjustable multi-point matched tooling. The numerical simulation was

used to investigate different methods and technique multi-point press forming by JLU and OENG. The mechanical element group of the multi-point press forming prototype was designed and punch element groups were built by JLU. The CAD/CAE software platform was developed with new models and interfaces by JLU and OENG. Partners SENER, OENG, JLU, CENAERO and CU(MEC) are involved in the exploitation. Many European aeronautic panel and forming tool fabrication companies were contacted and interviewed. SENER and JLU have set up cooperation with EADS in France on another multi-point forming system through providing technical parameters for forming test.
During the first year of the project, MEC and JLU also started cooperation with Bombardier Aerospace – Shorts in Belfast, UK through drafting and finalising NDA with Bombardier.
During the second year of the project, CU(MEC) received a response from Bombardier in Belfast with two CAD models of real panels and materials for testing and proofing**.** JLU has been finished the multi-point press forming test for two Bombardier's panels.
During the final year of the project, CU(MEC) was invited by Lufthansa Technik, Germany for presentation and was contacted by Barnes Aerospace USA and Bombardier in Canada.

A2: Dieless Multi-Point Press Forming Technologies (JLU, OENG, SENER, CU(MEC), KI and CENAERO)

Multi-point stretch forming technologies relates to methods, techniques, mechanical element group and CAD/CAE software for die-less forming large aircraft panels using one set of adjustable multi-point tooling. The numerical simulation were used to investigate different methods and technique multi-point stretch forming by JLU, CENARO, OENG, SENER and CU(MEC). The mechanical element group of the multi-point stretch forming prototype was designed and built by JLU. The CAD/CAE software platform was developed with new models and interface. Partners OENG, JLU, SENER, CENAERO and CU(MEC) are involved in the exploitation. Many European aeronautic panel and forming tool fabrication companies were contacted and interviewed.
During the first year of the project, OENG and JLU have set up cooperation with SONACA S.A. in Belgium on another multi-point stretch forming system through providing estimated quotation based on the technical requirement provide by SONACA and carrying out forming experiment with the sheet material provide by SONACA.
On 4th April 2008, all the members of DATAFORM consortium visited stretch forming workshop in SONACA, Gosselies, Belgium. A group meeting was organized between DATAFORM partners and SONACA The meeting on special technique presentation and exchange has been held in SONACA after visiting stretch forming workshop in SONACA. Managers and engineering from SONACA with researchers

from JLU (Prof. Mingzhe Li, Dr. Chunguo Liu and Mr Fuxing Tang) and OENG (Dr Igor Klapka, Dr Aimin Yan and Mr. Martin Santa Maria) discussed how to use Multi-Point Stretch Forming Tooling technology in SONACA stretching process
On 19th August 2008, fist two drafts of (Draft plan on cooperation with SONACA about the tests and possible application of multi-point stretch forming devices in SONACA, Agreement on Responsibility and Benefit Sharing in the case that SONACA buy the Multi-Point Stretch Forming prototype) was finished by Dr Aimin Yan and Dr Igor Klapka from OENG after receiving other partner's suggestion.

During the final year of the project, CU(MEC) was invited by Lufthansa Technik, Germany for presentation and was contacted by Barnes Aerospace USA and Bombardier in Canada. CU(MEC) also received a response from Lufthansa with 16 CAD models of real panels and materials for testing and proofing**.** JLU has been finished the multi-point press forming test for 8 Lufthansa's panels.

A3: Jigless Multi-Point Positioning Technologies (CU(MEC), KI, OENG, SENER, JLU, and CENAERO)

Multi-point positioning technologies relates to methods, techniques, mechanical design and CAD/CAE software for jig-less positioning formed aircraft panels using one set of adjustable multi-point tooling. The mechanical actuator group of the multi-point positioning tooling prototype was designed a by CU(MEC). The CAD/CAE/CAT software platform is being developed with new models and interface by OENG and KI. Partners SENER, OENG, JLU, CENAERO and CU(MEC) are involved in the exploitation. Many European aeronautic panel and assembly tool fabrication companies were contacted and interviewed.

A modified version of Production Tree report for commercial three DATAFORM tooling prototypes proposed by KI has been updated based on all DATAFORM partner's proposal.

B. Dissemination of knowledge

B1 Overview table for dissemination of knowledge

Planned/ actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
Oct. 2008 to Dec. 2009	Project news & References DATAFORM Website	General public	Worldwide	Thousands	CU(MEC)
Nov. 2008	Publication Chinese Journal of Plasticity Engineering	Research & Industry	Worldwide	Thousands	JLU
Dec. 2008	Publication Micro Manufacturing	Research & Industry	Worldwide	Thousands	CU(MEC)
Dec. 2008	Publication Aerospace engineering& manufacturing	Research & Industry	Worldwide	Thousands	SENER
Dec. 2008	Publication Chinese Journal of Mechanical Engineering	Research & Industry	Worldwide	Thousands	JLU
Jan. 2009	Presentation 2009 Manufacturing in FP7 Conference	Research & Industry	Worldwide	Hundreds	CU(MEC)
Jan. 2009	Presentation DATAFORM project	Industry	UK	15	CU(MEC)
Apr. 2009	Publication Int. J. Adv. Manuf Technol	Higher education & Research	Worldwide	Thousands	JLU
Sep. 2009	Conference & presentation World Hi-Tech Forum 2009	Higher education & Research	Worldwide	Thousands	CU(MEC)
Nov. 2009	Presentation DATAFORM project	Industry	Belgium	10	KI CU(MEC) OENG CENAERO

B2 Scientific publications and project news

The following is a list of the DATAFORM technical papers, web news publication, and presentation published in the final year:

- D. T. Pham, Voice of the MEC-Opinion… and big can be not bad, Micro Manufacturing, Vol. 1 No. 6 12, 2008, pp 48-49 http://www.mec.cf.ac.uk/services/docs/Micro_Manufacturing_Volume_1_issue_6%20(Big%20-%20DATAFORM).pdf
- SENER, Manufacturing: Europe investigation new aerospace press-forming possibilities, Aerospace engineering& manufacturing, Nov/Dec 2008, pp 30 http://www.dataform.mec.cf.ac.uk/Documents
- Tan Fuxing, Li Mingzhe, Cai Zhongyi ,Li Xiangji, Formability analysis on the process of Multi-point forming for titanium alloy retiary sheet, Int J Adv Manuf Technol, (*2009*) 41:1059~1065
- C.G. Liu, F.X.Tan. X.J.LI, Multi-point Positioning Tooling Technology for Aircraft Manufacturing, Material Science Forum, Vols. 628-629, PP517-522, 2009
- LIU Chun-guo, LI Ming-zhe, SUI Zhen, Application of multi-point methodology in the manufacturing of aircraft panels, Chinese Journal of Plasticity Engineering, Vol.15(2), 2008, p109-114, (*in Chinese*)
- TAN Fuxing, LI Mingzhe, CAI Zhongyi, Finite Element Analysis of Fractures in the Process of Digital Multi-point Forming for Retiary Sheet Metal, Chinese Journal of Mechanical Engineering, Vol.44, No.6, 2008, p120-124, (*in Chinese*)
- CU(MEC), World Hi-Tech Forum 2009, DATAFORM as a very good example of EU-Chinese cooperation in Aeronautics Research presented by Head of Unit H3 AERONAUTICS, EC http://www.dataform.mec.cf.ac.uk/News