FEA Information Inc.
Global News & Technical Information

SPECIAL EDITION

7th International LS-DYNA Users' Conference

Dedicated to the Global Engineering Community

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Purpose:
The purpose of our publication is to provide technical and industry information

In This Issue:

Review of the 7th International LS-DYNA Users Conference
Marsha J. Victory and Wayne L. Mindle, LSTC

Participant's of FEA Information Inc. contributed to making the 7th International LS-DYNA Users Conference an international success.

FEA Information Participants were well represented at the conference. They participated as session chairs, presenters, attendees, **exhibitors, and sponsors**:

ANSYS Bejing	**Dynalis - France**	**DYNAmore - Germany**
JRI – Japan	**THEME – Korea**	**Fujitsu – Japan**
CAD-FEM – Germany	**Kostech – Korea**	**STRELA – Russia**
ERAB – Sweden	**OASYS – UK**	**ANSYS - USA**
HP – USA	**SGI – USA**	**CEI – USA**
AMD - USA	**MSC.Software - USA**	**EASi – USA**
ETA - USA		

The conference was represented by over 21 countries, 475 attendees and 86 conference papers.

On Monday, May 20th at 8:35 a.m Dr. John O. Hallquist, President of LSTC, started the conference by introducing Tsuyoshi Yasuki, the General Project Manager of CAE Research, Development and Application Toyota Motor Company. Mr. Yasuki presented "Vehicle Crash Analysis Using Shell Element Type 16".

Tsuyoshi Yasuki, Toyota Motor Company

Following the opening presentation by Mr. Tsuyoshi Yasuki, Dr. Ted Belytschko, Walter P. Murphy Professor and Chair, Northwestern University presented "Recent Developments in Finite Element and mesh Free Methods".

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3 HP, LSTC, MSC.Sofware Web Seminar June 7th, 2002 11:00 am–- 12pm PST
For full detail package contact Marsha Victory of LSTC vic@lstc.com

Session Chairs:

Ren-Jye Yang	Ford Motor Company	**Majeed Bhatti**	General Motors Corporation
David Lu	Ford Motor Company	**Chung-Yeh Sa**	General Motors Corporation
Karl Schweizerhof	DYNAmore	**Fred Zweng**	DaimlerChrysler
Akbar Farahani	ETA	**Yi-Charng Deng**	General Motors Corporation
Mohammad Usman	Visteon	**Joseph Hassan**	DaimlerChrysler Corporation
Brian Walker	ARUP	**Charles Wawa**	General Motors Corporation
Mitsuhiro Makino	Fujitsu	**Li Zhang**	DaimlerChrysler Corporation
Russ Davidson	Lear Corporation	**Wei-Pin Wu**	Johnson Controls Incorporated
Alex Akkerman	Ford Motor Company	**John Shen**	DaimlerChrysler Corporation

The conference sessions were divided into the following categories:

- Crash/Safety
- Methods Development
- Simulation Technology
- Material Technology
- Fluid/Structure
- Code Technology
- Drop & Impact Simulation Technology
- Metal Forming Technology
- Computing Technology
- Computing Infrastructure
- Penetration and Explosive Modeling

The conference started with a welcome reception sponsored by Dell and Microsoft, which proved to be a relaxing and enjoyable way to meet friends and catch up on conversations.

All attendees were greeted at the Registration Desk with Conference Bags sponsored by Sun. Breakfast was provided both mornings and sponsored by NEC and IBM, respectively. Breaks during the sessions gave us time to visit exhibitors and enjoy quick refreshments sponsored by COMPAQ. Lunches were a welcome break to catch up on notes and meet others in an informal atmosphere. HP and Intel sponsored lunch the first day and SGI sponsored it on the second day. The conference banquet, sponsored by HP and Intel, was well attended on Monday night. The conference ended with a Farewell Reception sponsored by COMPAQ.

We are very pleased by the overall response of the attendees. Many first time participants and returning participants, sponsors and exhibitors indicated that they look forward to attending the 8th Conference in 2004.

We received many compliments about the quality of the conference and suggestions for improvement in the future. If we did not have a chance to speak with you please feel free to contact us with suggestions.

Wayne L. Mindle – wlm@lstc.com **Marsha J. Victory vic@lstc.com**

High Performance Compute Servers (HPC)
LS-DYNA on HPC Servers
Part 2 of 2
Brian Wainscott, LSTC

Industrial use of MPP-DYNA

As the computational demands of FEM simulation have grown over the past several years, with models continuing to grow in complexity, traditional solution methods have become inadequate. Applying distributed computing techniques, LSTC had developed a version of LS-DYNA that can run today's large models in reasonable times on a wide range of available hardware. In essence, the problem to be modeled is split into pieces (domains), and each piece is simulated on a different processor. Coordination between the simulations is of course required at the domain boundaries. Contact is a particularly difficult problem, requiring cooperation between all the processors as the domains interact. The communication involved produces overhead, which increases with the number of domains.

Consequently there is a limit to the speed that can be achieved. For a given problem, the simulation time generally goes down as the number of processors increases, up to a point. The speedup will drop off and, if too many processors are used, the simulation time will begin to increase. Here is one example of simulation run time as a function of the number of processors. In this example the problem is a 450,000 element crash model being run on a cluster of PCs.

# processors	***4***	***8***	***16***	***32***
CPU time	10930	5257	2847	1609
Speedup vs. 4	1.00	2.08	3.84	6.79
Speedup vs. 1	~ 4.00	8.32	15.36	27.16

These were only run to 10ms simulation time. The super linear speedup seen from 4 to 8 processors is a phenomenon that occasionally occurs. It is generally attributed to cache efficiency: each processor has a smaller piece of the problem, and this can result in better cache utilization.

Currently, the largest application areas for the MPP version of LS-DYNA are in automotive crash and metal forming. One of LSTC's customers has been running production sheet metal stamping simulations using MPP-DYNA for several years. Their problems routinely have 1 million elements, and they achieve overnight turnaround times utilizing a 30 processor system.

Recent advancements in PC hardware have brought these machines to the interest of large corporations as viable alternatives to vector supercomputers. One auto manufacturer has a rack mounted PC cluster of 384 processors on which they perform production simulations utilizing MPP-DYNA. They can run 24 simultaneous 16 processor problems, and have overnight turnaround on typical crash models with over 600,000 elements. Another carmaker recently benchmarked a PC cluster using a 700,000 node ODB (offset deformable barrier impact) model. They found that running on 7 processors they could match the speed of their current model vector supercomputer. On 48 processors it was 7 times faster, and still scaling. This kind of speed is simply unattainable using traditional SMP programming techniques as implemented in LS-DYNA.

Distributed implicit solution methods are currently under development at LSTC. Implicit methods are better suited to certain kinds of problems than explicit methods. By extending the implicit method to a distributed system, the memory and computational power needed to solve large complex systems is readily available. The delay in the implicit methodology in LS-DYNA is primarily related to the effort required to add constitutive matrices to each material model, the implicit extension of every constraint option including contact, and the development of stiffness matrices for each explicit element. This work is nearing completion so our efforts will now center on the MPP implementation.

AMD Anthlon ™ MP Processor

DaimlerChrysler Chooses AMD-Based Server for Enterprise Computing

The AMD Athlon(tm) MP Processor

The AMD Athlon MP processor is a seventh-generation x86 processor designed for high-performance multiprocessing servers and high end workstations. A key advantage of AMD's multiprocessing platform is Smart MP technology, which greatly enhances overall platform performance by increasing data movement between the two CPUs, chipset and memory system. Smart MP technology features dual point-to-point, high-speed 266MHz system buses with Error Correcting Code (ECC) support designed to provide up to 2.1 GB per second per CPU of bus bandwidth in a dual- processor system.

Smart MP technology also has an optimized Modified Owner Exclusive Shared Invalid (MOESI) cache coherency protocol that manages data and memory traffic in a multiprocessing environment.

The new AMD Athlon MP processor features the patented QuantiSpeed architecture, which includes a high performance full-speed cache with hardware data pre-fetch, a fully pipelined superscalar floating point engine, and an exclusive L2 Translation Look-aside Buffer (TLB). The processor also incorporates 3DNow!* Professional technology, which has 51 new instructions that extend AMD's 3DNow! technology, enabling smoother, richer and more lifelike images, more precise digital audio and an enriched Internet experience. The AMD Athlon MP processor is compatible with AMD's stable Socket A infrastructure, and supports DDR memory technology.

GENEVA, SWITZERLAND-DECEMBER 19, 2001-AMD (NYSE: AMD) announcement:

DaimlerChrysler AG has implemented a server powered by the AMD Athlon(tm) MP processor 1800+ in its Mercedes-Benz Technology Center (MTC) in Germany. Based on AMD's advanced multiprocessing solution, DaimlerChrysler is utilizing the strength of several hundred AMD Athlon MP processors in one of the largest high-performance Linux clusters in the German automotive industry, to run crash simulations for Mercedes-Benz vehicles.

DaimlerChrysler's crash simulation team selected the AMD Athlon MP processor-based solution because it delivers superior performance and stability on single and dual processor-based servers for enterprise class applications.

"We evaluated many solutions and concluded that the AMD Athlon MP processor-based server was the best choice in terms of performance and stability," said Dr. Johannes Luginsland, manager IT infrastructure for safety and comfort simulation, DaimlerChrysler. "The AMD Athlon MP processor's extraordinary floating point capabilities coupled with AMD's Smart MP technology deliver the superior performance we need for mission-critical supercomputing. Shortened product development processes made possible by gains in computer aided engineering require increasingly demanding simulations that must be carried out in less time. This demands the appropriate computer processing capability."

"DaimlerChrysler's choice reflects the increasing confidence that market-leading multinational companies have in AMD's technology," said Giuliano Meroni, vice president, sales and marketing, AMD Europe. "Superior architectural features like QuantiSpeed(tm) and AMD's Smart MP technology set our solution apart."

AMD on the Web

For more AMD news and product information, please visit our virtual pressroom at www.amd.com/news/virtualpress/index.html. Additional press releases are available at www.amd.com/news/news.html.

7th International LS-DYNA conference

Arthur B. Shapiro, of LLNL, representing Strella, the LS-DYNA distributor in Russia is shown discussing the key benefits of Athlon Architecture and MPP LS-DYNA on Linux Clusters with Beatriz Hubert. Currently, the largest application areas for the MPP version of LS-DYNA are in automotive crash and metal forming.

During the presentation at the AMD booth at the 7th International LS-DYNA conference AMD presented the following key points about the benefits of the Athlon Architecture:

- Nine-issue superscalar, fully pipelined micro-architecture increase processor efficiency
- Three-way superscalar pipelined Floating Point Unit with super data forwarding to offer superior scalable scientific computing performance.
- MP chips feature Hardware prefetch to lower memory latency/bandwidth and a large split 128KB instruction/data cache
- Support for Double Data-Rate (DDR) memory and point-to-point high speed system buses Error Checking Code (ECC) support for performance and reliability.

FEA Information Inc. May Showcased Presentation
From the 7th International LS-DYNA Users Conference

Improvements to the Beverage Can Redraw Process Using LSDYNA

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ABSTRACT

In the United States, in the year 2000, over 100 billion aluminum beverage cans were manufactured. Lightweighting of these aluminum D&I beverage cans has been a continuous process for more than 35 years. Aluminum beverage can "ends" have been made progressively smaller over the years in order to reduce costs. Likewise, cost control efforts have resulted in continuous reduction of the net metal requirements for the can body. To reduce the weight and cost of the "bodies", cans with thinner sidewalls, reduced neck diameters and smaller base diameters have been developed. The reduction in cost has been achieved while maintaining functionality, structural performance, and formability of the can. Today, the gauge of can body stock is as low as 0.0098 inches. With small base diameter cans and a sheet thickness that continues to decrease, the likelihood of profile wrinkling during can forming increases, particularly in the redraw process. Redraw wrinkling is influenced by many factors such as mechanical properties of the aluminum sheet, tooling geometry, contact conditions including the effects of lubrication, and process boundary conditions. These factors are readily handled using the finite element method. A numerical technique for calculating the severity of the redraw wrinkling or wrinkle factor from an LSDYNA finite element analysis is employed. Using this wrinkle factor, and a fully parametric input generator, improvements to the beverage can redraw process are developed.

BACKGROUND

In the United States, lightweighting of aluminum drawn and ironed (D&I) beverage cans has been a continuous process for over 35 years. Advances in can manufacturing technology and cost control efforts by aluminum suppliers, canmakers, and fillers have resulted in a consistent reduction of the net metal weight and cost of the beverage can. Since its inception, the gauge of the aluminum D&I can body stock has decreased from approximately 0.0200 inches to today's thickness of 0.0100 inches. This has resulted in a reduction of net can weight from 39 lbs. per 1000 cans to 23 lbs. per 1000 cans. This reduction in weight has been achieved without compromise to the structural integrity or performance of the can. The performance requirements include dome reversal pressure, axial column load, drop resistance, and can growth.

To reduce the weight and cost of the can bodies, cans with thinner sidewalls, reduced neck diameters and smaller base diameters have been developed. With small base diameter cans and light gauge material, the likelihood of wrinkling during can manufacturing increases, particularly in the redraw process. A schematic of the redraw process is provided in Figure 1. A photograph showing typical redraw wrinkling is provided in Figure 2. Manufacturing experience demonstrates that redraw wrinkling is influenced by many factors such as mechanical properties of the aluminum sheet, tooling geometry, contact conditions including the effects of lubrication, and process boundary conditions. The most common wrinkling control techniques include increased redraw sleeve pressure, reduced redraw sleeve radius, reduced redraw die radius, and increased cup diameter. However, all of these methods provide increased resistance to metal flow which can lead to increased thinning and fracture in the sheet metal under the punch nose.

A numerical technique for calculating the severity of the redraw wrinkling or wrinkle factor from an LSDYNA finite element analysis is employed. Using this wrinkle factor, and a fully parametric input generator, improvements to the beverage can redraw process are developed. Effects of punch speed, friction conditions, cup and punch geometry, and material characteristics on formability are investigated. The formability is evaluated by monitoring both wrinkling and localized thinning during the redraw process.

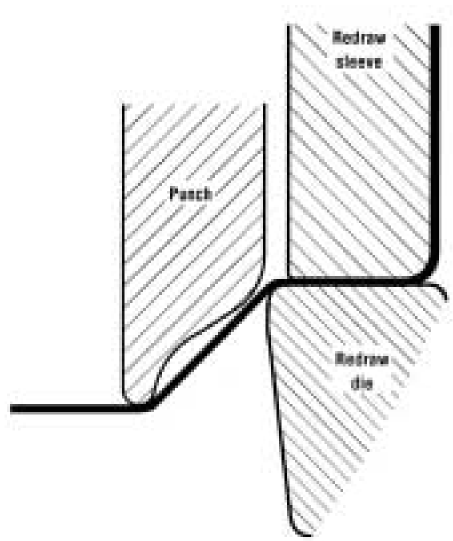


Figure 1. Schematic of cup redraw process.

Figure 2. Photograph of redrawn beverage can showing profile wrinkles.

WRINKLE FACTOR CALCULATION

Finite element models were assembled to investigate the severity of wrinkling during the redraw process. All input data files for the fully parametric LS-DYNA models were generated using the LS-INGRID pre-processor. A list of the baseline parameters for the redraw simulations is provided in Table 1. The nomenclature used for the redraw tooling parameters is depicted in Figure 3. All the models employ 1/4 symmetry. The modeled tooling consists of the punch, redraw sleeve, and redraw die. The cup geometry is idealized and has uniform metal thickness. No history of cup forming is accounted for in the redraw model. The material model used is an elastic-plastic von Mises material with isotropic hardening. Young's modulus is 10 million psi and Poisson's ratio is 0.33. Sliding interfaces (type 10) are used to model the contact between the cup profile and rigid tooling. A coefficient of friction of 0.05 was used for all contact interfaces between the rigid tools and the deformable cup. A total punch displacement of 0.9 inches was applied in 0.025 seconds resulting in a maximum punch speed 40.0 inches/sec. A constant redraw sleeve force of 2500 lbs. was applied.

The initial cup geometry and typical deformed shape of a partially redrawn cup are provided in Figure 4. A radial coordinate contour plot of the wrinkled profile of the cup is shown in Figure 5. The plot shows the radial distance and circumferential position for each ring of nodes in the wrinkled region of the cup profile. The wrinkle factor is calculated as the percentage of the maximum normalized arc length relative to the unit length calculated from each contour in the radial coordinate plot data. A wrinkle factor of zero indicates no wrinkling. The wrinkle factor for the redrawn cup shown is 5.12. Predicted wrinkle factors and percent thickness reduction for all cases studied in the paper are provided in Appendix A.

Table 1
Cup Redraw Model - Baseline Conditions
(inches)

Punch Dimensions

Base Diameter	*1.866*
Punch Diameter	*2.603*
Inside Nose Radius	*0.060*
Outside Nose Radius	*0.060*
Profile Radius	*0.120*
Lower Body Radius	*0.200*
Profile Height	*0.365*
Lower Transition Length	*0.350*
Thinwall Length	*0.500*
Outside Nose Angle (degrees)	*65.000*
Lower Body Angle (degrees)	*28.000*

Redraw Sleeve Dimensions

Sleeve Inside Diameter	*2.650*
Sleeve Outside Diameter	*3.592*
Sleeve Inside Corner Radius	*0.030*
Sleeve Outside Corner Radius	*0.075*
Sleeve Taper Length	*0.500*
Sleeve Height	*1.500*
Sleeve Taper Angle (degrees)	*0.000*

Alcoa Redraw Die Dimensions

Die Inside Diameter	*2.635*
Die Outside Diameter	*4.100*
Die Radius	*0.090*
Die Finish Radii	*0.040*
Landing Offset	*0.105*
Landing Length	*0.025*
Die Height	*0.750*
Die Entry Angle (degrees)	*8.000*
Die Relief Angle (degrees)	*8.000*

Cup Dimensions

Cup Inside Diameter	*3.598*
Cup Corner Radius	*0.078*
Cup Height	*1.500*
Cup Thickness	*0.0108*

Material Constants

Voce Constant - A (psi)	*48328*

Voce Constant - B (psi)	*6978*
Voce Constant - C	*34.67*

Friction, Loads, Motion

Punch Friction (μ)	*0.050*
Sleeve Friction(μ)	*0.050*
Die Friction(μ)	*0.050*
Redraw Sleeve Force (lbs)	*2500*
Punch Displacement	*0.900*

Duration Time

Cycle Time (ms)	*0.025*

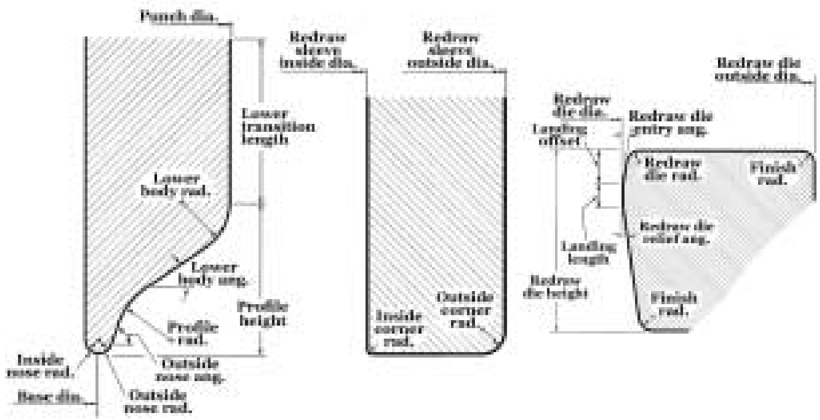


Figure 3. Nomenclature for redraw tooling.

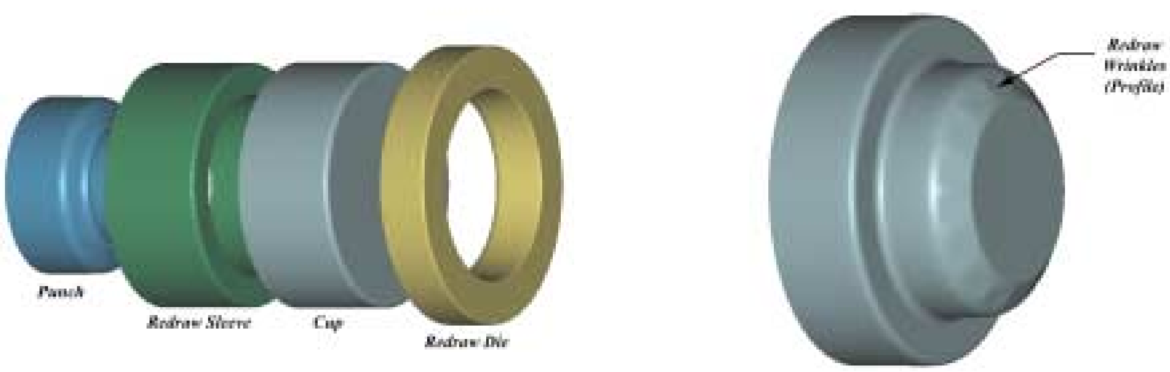


Figure 4. Initial geometry and partially redrawn cup showing wrinkles.

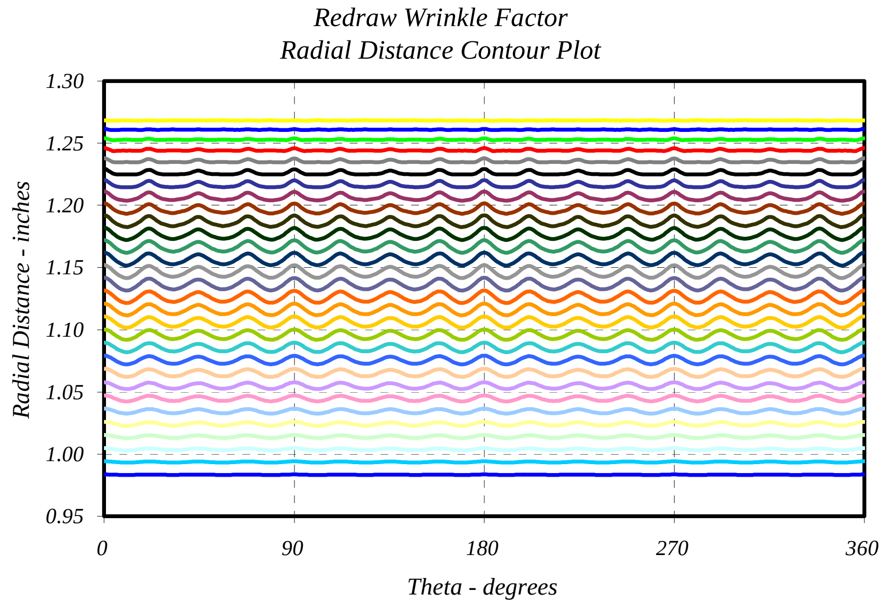


Figure 5. Radial distance contour plot for partially redrawn cup.

PUNCH SPEED

Analyses were performed to determine the influence of maximum punch speed on the predicted wrinkling factor. The total punch displacement of 0.9 inches was applied at time periods ranging from 0.010 seconds to 0.150 seconds using a smoothed load curve. The resulting maximum punch speeds range from 100.0 inches/sec to 6.67 inches/sec. The results are provided in Figure 6 and indicate that as the punch speed increases, the severity of wrinkling decreases.

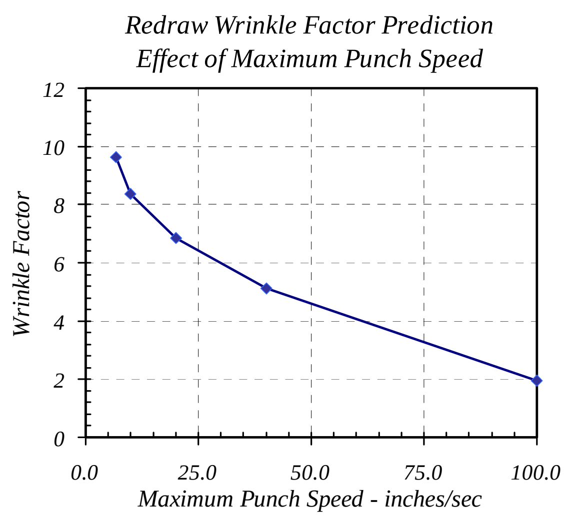


Figure 5. Effect of punch velocity on the predicted redraw wrinkling factor.

FRICTION

Friction is controlled commercially through the application of lubricants. Coefficient of friction values were varied from a nearly frictionless condition of 0.001 to a value of 0.1. The influence of coefficient of friction between the rigid tools and the cup is shown in Figure 7. The data shows a significant increase in the wrinkle factor as a frictionless condition is approached. Also, as friction increases the restraining forces on the cup increases leading to increased thinning in the metal under the punch nose. High coefficients of friction can lead to dome fractures or "punch-outs".

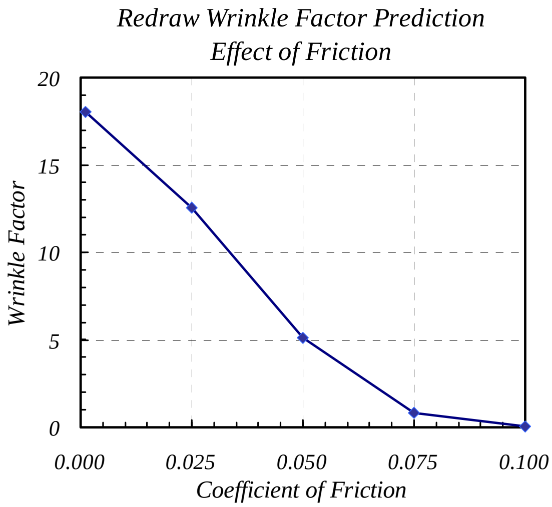
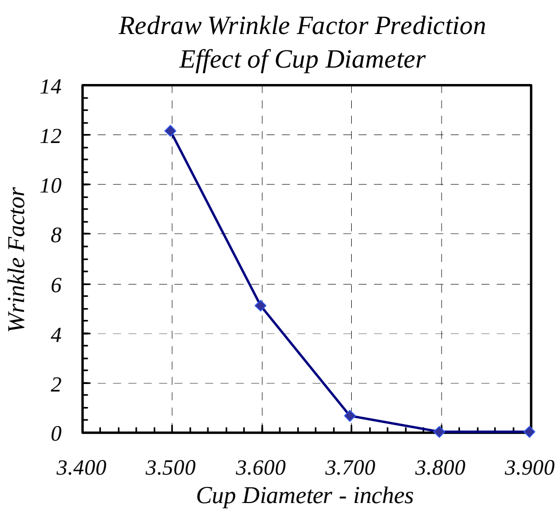


Figure 7. Influence of coefficient of friction on the predicted redraw wrinkle factor.

CUP GEOMETRY

The influence of the cup geometry was examined by varying the cup diameter and cup thickness. The cup diameter ranged from 3.498 inches to 3.798 inches. The metal thickness varied from 0.0096 inches to 0.0114 inches. The results are summarized in Figure 8. The data indicates that as both the cup diameter and thickness increase, the severity of wrinkling decreases.



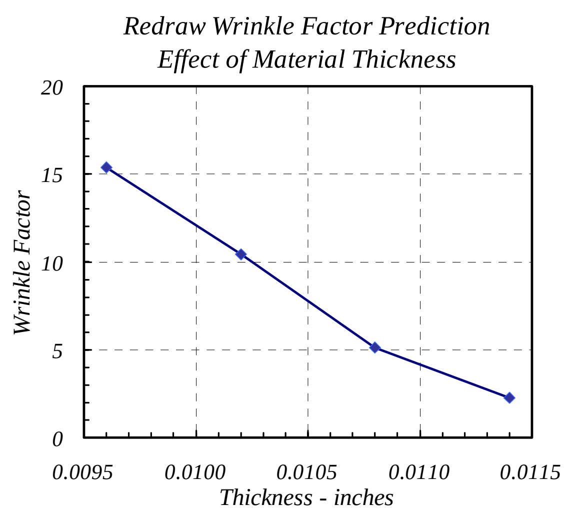


Figure 8. Effect of cup diameter and metal thickness on the predicted redraw wrinkle factor.

PUNCH GEOMETRY

The influence of punch geometry on the predicted wrinkling factor was investigated by varying the profile height which ranged from 0.355 inches to 0.385 inches. While many factors could be adjusted, the profile height is considered to be the one of the most critical. The results are plotted in Figure 9 and show increased wrinkling with increased profile height.

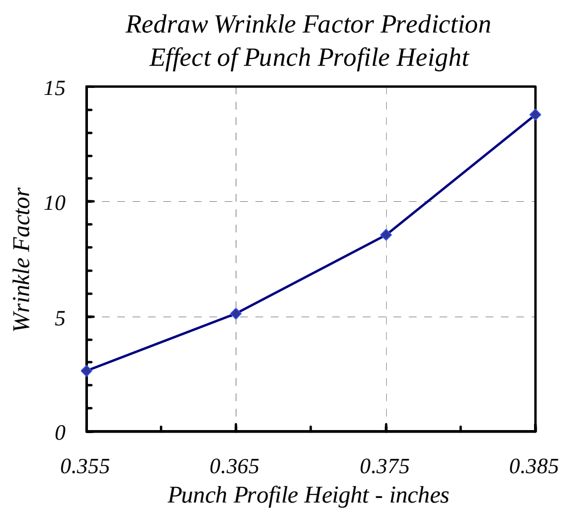


Figure 9. Effect of punch profile height on the predicted redraw wrinkle factor.

MATERIAL

The effects of material characteristics were evaluated by modifying yield stress, strain hardening, and strain hardening rate. The material flow stress was described using the Voce equation:

$$\sigma = A\text{-}B \cdot exp(\text{-}C\varepsilon) \qquad (1)$$

which may be re-written as:

$$\sigma = A\text{-}(A\text{-}YS) \cdot exp(\text{-}C\varepsilon) \qquad (2)$$

where σ is the true stress, ε is the true plastic strain, A, B, C are the Voce material constants and YS is the yield strength. The complete experimental design is given in Table 2. The range of values chosen is considered typical of *as-rolled* properties for existing body stock alloys. Runs 1-15 are a central-composite design at three levels of yield strength (A-B), asymptote or tensile strength (A), and strain hardening rate (C) as shown in Figure 10. This design allows the estimation of quadratic and interaction effects. Run 18 augments run 16 with low rate (low asymptote, mid-yield strength) while run 19 augments run 17 with low rate (high asymptote, higher strength).

Table 2
Voce Material Coefficients

Run ID	A (psi)	B (psi)	C	YS (psi)	Wrinkle Factor	%Thick Reduction
1	48328	6978	17.335	41350	4.650	5.17
2	48328	6978	34.67	41350	5.116	5.23
3	48328	7633	26.0025	40695	4.335	5.05
4	48328	8288	17.335	40040	3.585	4.98
5	48328	8288	34.67	40040	3.915	5.07
6	50479	9129	26.0025	41350	4.157	4.97
7	50479	9784	17.335	40695	3.364	4.98
8	50479	9784	26.0025	40695	3.684	4.94
9	50479	9784	34.67	40695	4.037	5.00
10	50479	10439	26.0025	40040	3.052	5.00
11	52630	11280	17.335	41350	3.645	4.99
12	52630	11280	34.67	41350	3.983	5.19
13	52630	11935	26.0025	40695	3.190	5.20
14	52630	12590	17.7	40040	2.422	5.15
15	52630	12590	34.67	40040	2.959	5.32
16	45587	4892	34.67	40695	5.172	5.41
17	54479	9784	34.67	44695	6.869	5.16
18	45587	4892	17.335	40695	4.979	5.50
19	54479	9784	17.335	44695	6.517	5.02

The results show that only linear terms were statistically significant with no significant curvature or interactions over the range of parameters studied. The fitted equation is given by:

$$\boldsymbol{wf} = -23.61 - 2.55\text{E-}04 \cdot \boldsymbol{A} + 2.39\text{E-}02 \cdot \boldsymbol{C} + 9.74\text{E-}04 \cdot \boldsymbol{YS} \qquad (3)$$

where *wf* is the predicted redraw wrinkle factor. This implies that redraw wrinkling is minimized when the yield stress is low, the asymptote is high, and the hardening rate is low. Lowering the yield stress provides the greatest reduction on wrinkling followed by increasing the asymptote or tensile strength and then decreasing the hardening rate.

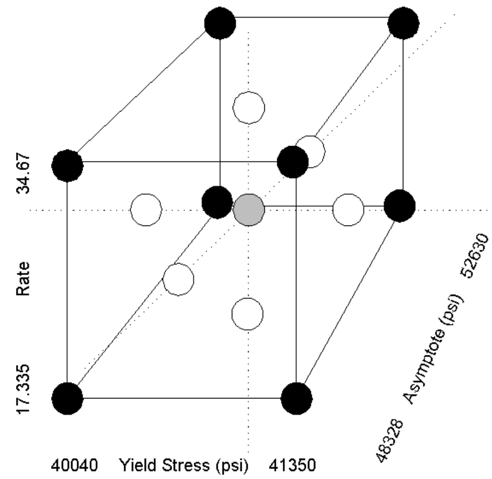


Figure 10. Experimental Design (15 Central-Composite Runs Only)

SUMMARY

Software tools have been developed to quantify the magnitude and frequency of wrinkles in the cup redraw process. These tools can be used to evaluate the effects of tooling geometry, material characteristics (anisotropy, yield strength and work hardening), and boundary conditions (redraw sleeve force and friction) on redraw wrinkling. The results presented confirm the trends based on manufacturing experience. The analysis of loading rate demonstrated that increased punch velocity reduced the amplitude of redraw wrinkling. The study of friction indicated the effects of friction are significant in the prevention of redraw wrinkling and the severity of wrinkling increases as the coefficient of friction decreases. The amount of localized thinning also increased with increased friction. It was concluded the effects of lubrication must be balanced between wrinkling prevention and localized thinning. The examination of cup geometry demonstrated that increased cup diameter and increased thickness reduce redraw wrinkling. However, to minimize costs, increasing metal gauge is generally not feasible. Punch design changes, such as reduced profile heights, can also minimize redraw wrinkling. Lower profile heights can reduce wrinkling but produce domes with decreased dome reversal pressures and increased can growth. Finally, the study on material characteristics indicated that when yield stress is low, the tensile stress is high, and the hardening rate is low, redraw wrinkling is minimized. The most significant material factor affecting redraw wrinkling is the as-rolled yield stress.

There is a trade-off between wrinkling and structural performance. Factors that control or reduce wrinkling may also affect localized thinning or structural performance. An acceptable solution must balance formability and structural performance requirements.

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Appendix A

Summary Table.
Wrinkle Factors and Percent Thickness Reduction

Identification	Wrinkle Factor	% Thickness Reduction
SPEED1(100 inches/sec)	1.96	5.62
SPEED2 (40 inches//sec)	5.12	5.23
SPEED3 (20 inches/sec)	6.85	5.31
SPEED4 (10 inches/sec)	8.36	5.44
SPEED5 (6.67 inches/sec)	9.65	5.45
FRICTION1 (μ=0.001)	18.05	5.29
FRICTION2 (μ=0.025)	12.55	5.24
FRICTION3 (μ=0.050)	5.12	5.23
FRICTION4 (μ=0.075)	0.80	5.44
FRICTION5 (μ=0.100)	0.04	6.04
CUPSIZE1 (3.498)	12.18	5.70
CUPSIZE2 (3.598)	5.12	5.23
CUPSIZE3 (3.698)	0.67	6.42
CUPSIZE4 (3.798)	0.04	7.31
CUPSIZE5 (3.898)	0.04	7.78
THICKNESS1 (0.0096)	15.36	4.95
THICKNESS2 (0.0102)	10.42	5.18
THICKNESS3 (0.0108)	5.12	5.23
THICKNESS4 (0.0114)	2.25	5.54
PHEIGHT1 (0.355)	2.64	5.22
PHEIGHT1 (0.365)	5.12	5.23
PHEIGHT1 (0.375)	8.56	5.64
PHEIGHT1 (0.385)	13.78	6.29

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April 01	Dynamore	Contributed AVI Bicycle Helmet Impact
	MSC.Software	Linux Clusters
	LEAP	Distributor in Australia
April 08	LSTC	Keyword 960 available on line to download
	JRI	JVISION pre and post processor
	SGI	Origin 200
	CAD-FEM GmbH	Distributor in Germany
April 15	ETA	FEMB (Finite Element Model Builder)
	OASYS	Oasys Primer
	MFAC	Distributor in Canada
April 22	Hewlett-Packard	HP Vectra v 1800
	EASi Engineering	EASi-CRASH
	Dynamax	Distributor USA
April 29	Alexey I. Borokov	Contributed AVI LS-DYNA
	Fujitsu	Parallel Server AP3000
	LMS Int'l	LMP Optimus
	ERAB	Distributor in Sweden

EVENTS – see events on www.feainformation.com for details

2002		
Sept 16 – 17	Sweden	Nordic LS-DYNA Users' Conference
Oct. 03-04	Italy	Engin Soft Conference and User's Meeting
Oct. 08	UK	OASYS LS-DYNA Update Meeting
Oct. 09-11	Germany	CAD-FEM Users Meeting - Germany
Oct. 10-13	USA	10th Foresight Institute Conference on Molecular Nanotechnology
Oct. 24 – 25	Japan	Japanese LS-DYNA & JMAG Users Conference
Oct. 28	Korea	Korean LS-DYNA Users Conference
Dec 18 – 21	India	HiPC 2002
2003		
May 19-21	USA	BETECH2003
May 22-23	Germany	4th European LS-DYNA Conference
June 17-20	USA	The Second M.I.T Conference on Computational Fluid and Solid Mechanics

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Japan	Fujitsu Ltd.	www.fujitsu.com
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Korea	Korean Simulation Technologies	www.kostech.co.kr
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