

***CONTROL_FORMING_STONING**

Purpose: This feature is developed to detect surface lows or surface defects formed during metal stamping. This calculation is typically performed after a springback simulation. A curvature-based method is implemented with the feature. Users have the option to check an entire part or just a few local areas, defined by node set or shell element set. In each area, direction of the stoning action can be specified by two nodes (see **Remarks** below) or simply allow the program to automatically determine the stoning direction.

Card Format (I10, 4E10.0, 2I10)

Card 1 1 2 3 4 5 6 7 8

Variable	ISTONE	LENGTH	WIDTH	STEP	DIRECT	REVERSE	METHOD	
Type	I	F	F	F	F	I	I	
Default	None	0.0	0.0	0.0	0.0	0	0	

Card Format (4I10)

Card 2 1 2 3 4 5 6 7 8

Variable	NODE1	NODE2	SID	ITYPE	V1	V2	V3	
Type	I	I	I	I	F	F	F	
Default	0	0	0	0	0.0	0.0	0.0	

<u>VARIABLE</u>	<u>DESCRIPTION</u>
ISTONE	Stoning calculation option. EQ.1: calculate panel surface quality using stoning method.
LENGTH	Length of the stone.
WIDTH	Width of the stone.
STEP	Stepping size of the moving stone.
DIRECT	Number of automatically determined stoning direction(s).

<u>VARIABLE</u>	<u>DESCRIPTION</u>
REVERSE	Surface normal reversing option. EQ.0: do not reverse surface normals. EQ.1: reverse surface normals.
METHOD	Stoning method. EQ.0: curvature-based method.
NODE1	Tail node defining stoning moving direction.
NODE2	Head node defining stoning moving direction.
SID	Node or shell set ID.
ITYPE	Set type designation. EQ.1: node set. EQ.2: element set.
V1, V2, V3	Vector components defining stoning direction (optional).

Remarks:

1. Stoning is a quality checking process on class-A exterior stamping panels. Typically the long and wider surfaces of an oil stone of a brick shape are used to slide and scratch in a given direction against a localized area of concern on a stamped panel. Surface ‘lows’ are shown where scratch marks are not visible and ‘highs’ are shown in a form of scratch marks. This keyword is capable of predicting both the surface ‘lows’ and ‘highs’. Since stoning process is carried out after the stamping (either drawn or trimmed) panels are removed from the stamping dies, a springback simulation needs to be performed prior to conducting a stoning analysis.
2. As a reference, typical stone length and width can be set at 150.0 and 30.0 mm, respectively.
3. The Step size of the moving stone is typically in the order of the element length. The smallest element length can be selected as the step size.
4. The variable DIRECT allows for the automatic definition of the stoning directions. Any number can be selected but typically ‘2’ is used. Although CPU time required for the stoning calculation is trivial, a larger DIRECT consumes more CPU time.
5. Stoning is performed on the outward normal side of the mesh. Element normals must be oriented accordingly and consistently. Alternatively, the variable REVERSE provides an easy way to reverse the element normals in the solver before the computation.
6. Variables NODE1 and NODE2 are used to define a specific stoning direction. The stone is moved in the direction defined by NODE1 to NODE2. Alternatively, one can leave NODE1 and NODE2 blank and define the number of automatically determined stoning

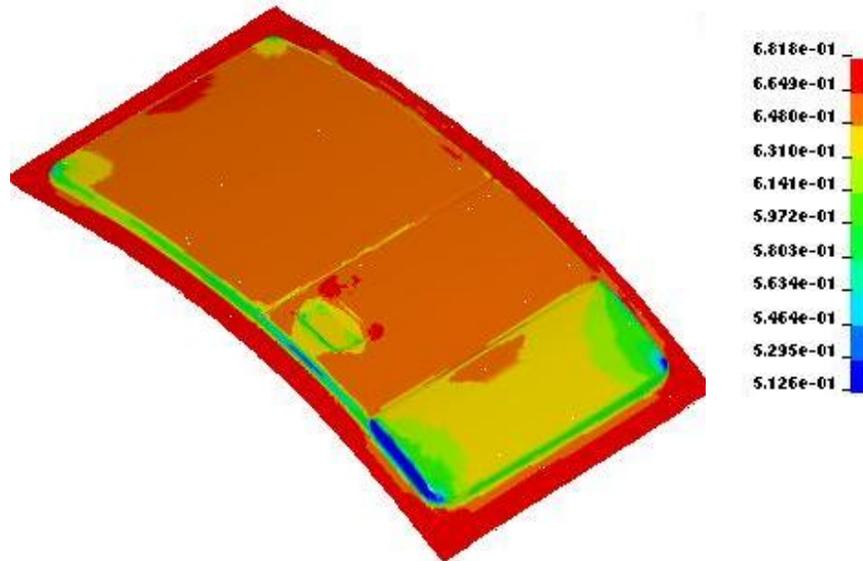
directions by using DIRECT. Furthermore, stoning direction can also be defined using a vector by defining V1, V2, V3.

7. The blank model intended for analysis can be included using keyword *INCLUDE. If nothing is defined for SID and ITYPE then the entire blank model included will be used for stoning analysis.
8. A large area mesh can be included in the input file. An ELSET must also be included, which defines a local area that requires stoning computation. Alternatively, an ELSET can define several local areas to be used for the computation. Furthermore, an ELSET should not include meshes that have reversed curvatures. An ELSET can be easily generated using LS-PrePost, in page 5, under SetD.
9. Since stoning requires high level of accuracy in springback prediction, it is recommended that the SMOOTH option in keyword *CONTACT_FORMING_ONE_WAY_SURFACE_TO_SURFACE to be used during the draw forming simulation. Not all areas require SMOOTH contact, only areas of interest may apply. In addition, meshes in the areas of concern need to be very fine, with average element size of 1 to 2 mm. Mesh adaptivity is not recommended. Mass scaling with DT2MS needs to be sufficiently small to reduce the dynamic effect during forming. For binder closing of large exterior panel, implicit static method using *CONTROL_IMPLICIT_FORMING type 2 is recommended.
10. It is recommended that double precision version of LS-DYNA be used for this application.
11. The output of the stoning simulation results is in a file named “filename.output”, where “filename” is the name of the LS-DYNA stoning input file contains this keyword, without the file extension. The stoning results can be viewed using LS-PrePost, in page 1, under FCOMP/Thick/ Shell_Thickness.
12. The stoning feature is available in LS-DYNA R5 Revision 54398 or later releases. Vector component option is available in R5 Revision 60829 or later releases. An example of a stoning analysis on a Ford Econoline door outer panel is provided below for reference. The original part model comes from National Crash Analysis Center at The George Washington University. The complete input deck used for the stoning simulation is provided below for reference; where, a local area mesh of the door handle after springback simulation ‘Doorhandle.k’ and an element set ‘elset1.k’ are included in the deck.

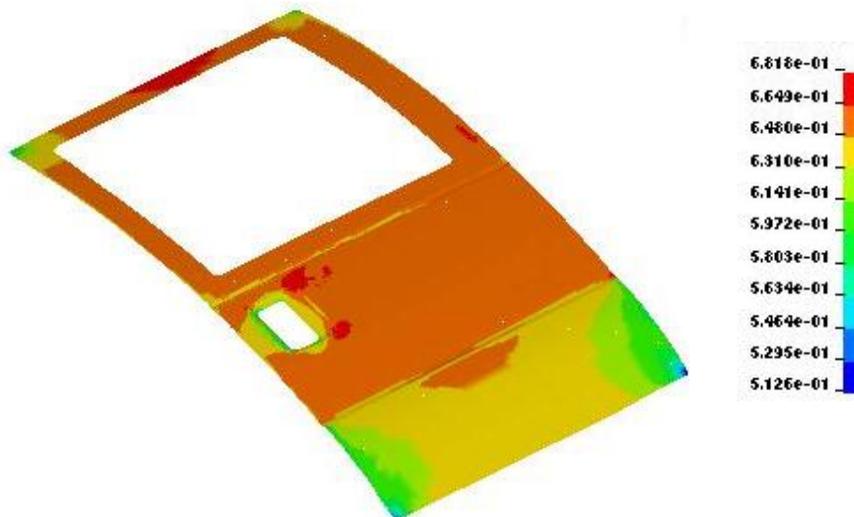
*CONTROL

*CONTROL_FORMING_STONING

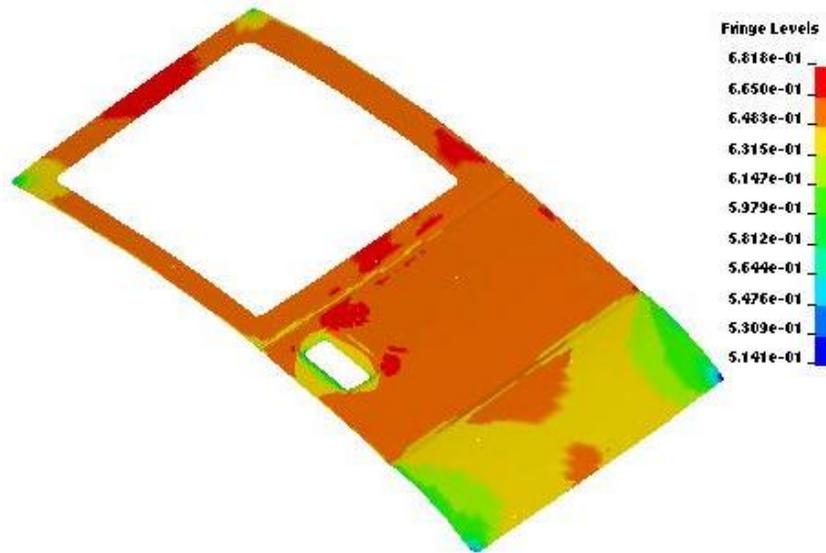
```
*KEYWORD
*TITLE
Stoning Analysis
*INCLUDE
Doorhandle.k
*INCLUDE
elset1.k
*CONTROL_FORMING_STONING
$  ISTONE   LENGTH   WIDTH   STEP   DIRECT  REVERSE  METHOD
    1       150.0    4.0     1.0     2        0         0
$  NODE1    NODE2     SID     ITYPE
    1        1        1         2
*END
```



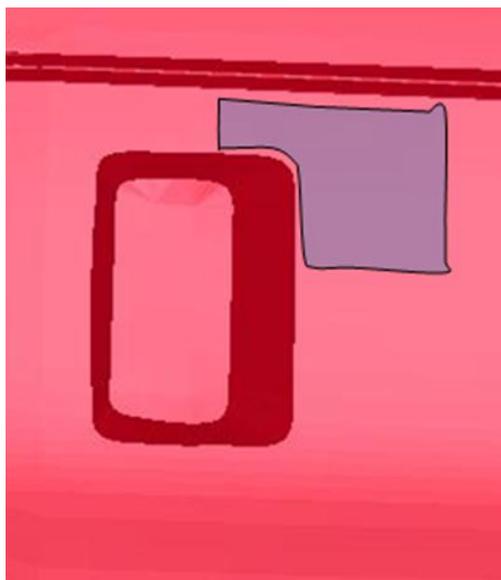
Thickness contour of the panel after draw simulation



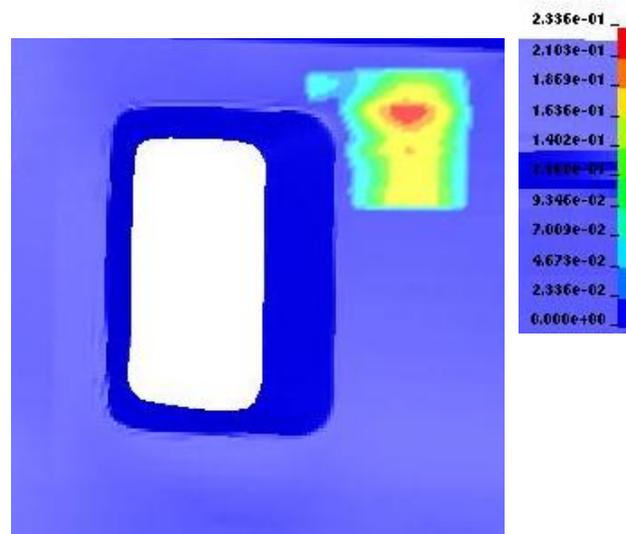
Thickness contour of the panel after trimming



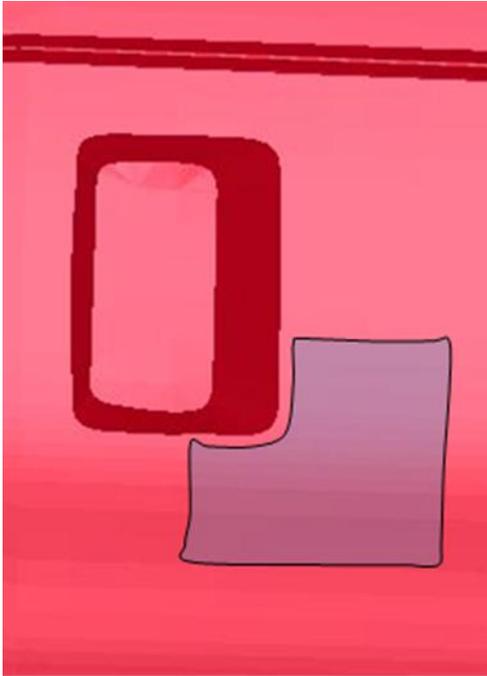
Springback amount (mm) in Z is shown in the figure below.



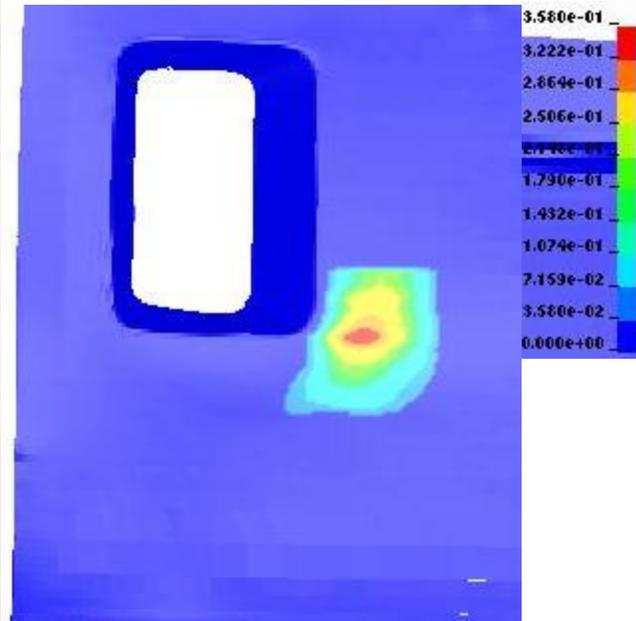
The element sets selected for stoning



Stoning results



The element sets selected for stoning



Stoning results