*CONTROL_FORMING_SCRAP_FALL

Purpose: This keyword allows for contact-based trimming of scrap fall simulation in a sheet metal stamping press, and it applies to shell elements only.

Scrap Part Cards. Repeat Card as many times as needed to define multiple scrap pieces. The next "*" card terminates the input.

Card 1	1	2	3	4	5	6	7	8
Variable	PID	VECTID	NDSET	LCID	DEPTH	DIST		
Type	I	I	I	I	F	F		
Default	none	none	none	none	none	none		

VARIABLE	DESCRIPTION
PID	Part ID of the scrap piece to be trimmed away.
VECTID	Vector ID for a trim steel movement, as defined by *DEFINE_VECTOR. If left undefined (blank), global Z direction is assumed.
NDSET	A node set consists of all nodes along the cutting edge of the trim steel.
LCID	Load curve ID governing the trim steel kinematics, as defined by *DEFINE_CURVE. GT.0: velocity-controlled kinematics LT.0: displacement-controlled kinematics An example input deck is provided below.
DEPTH	A small penetrating distance between the cutting edge of the trim steel and the scrap piece, as shown in Figure **0-2**. Nodes along the scrap edge are released from automatically-added constraints at the simulation start and free to move after this distance is reached.
DIST	A distance tolerance measured in the plane normal to the trim steel moving direction, between nodes along the cutting edge of the trim steel defined by NDSET and nodes along an edge of the scrap, as shown in Figure **0-1**. This tolerance is used to determine if the constraints need to be added at the simulation start to the nodes along the trim edge of the scrap piece.

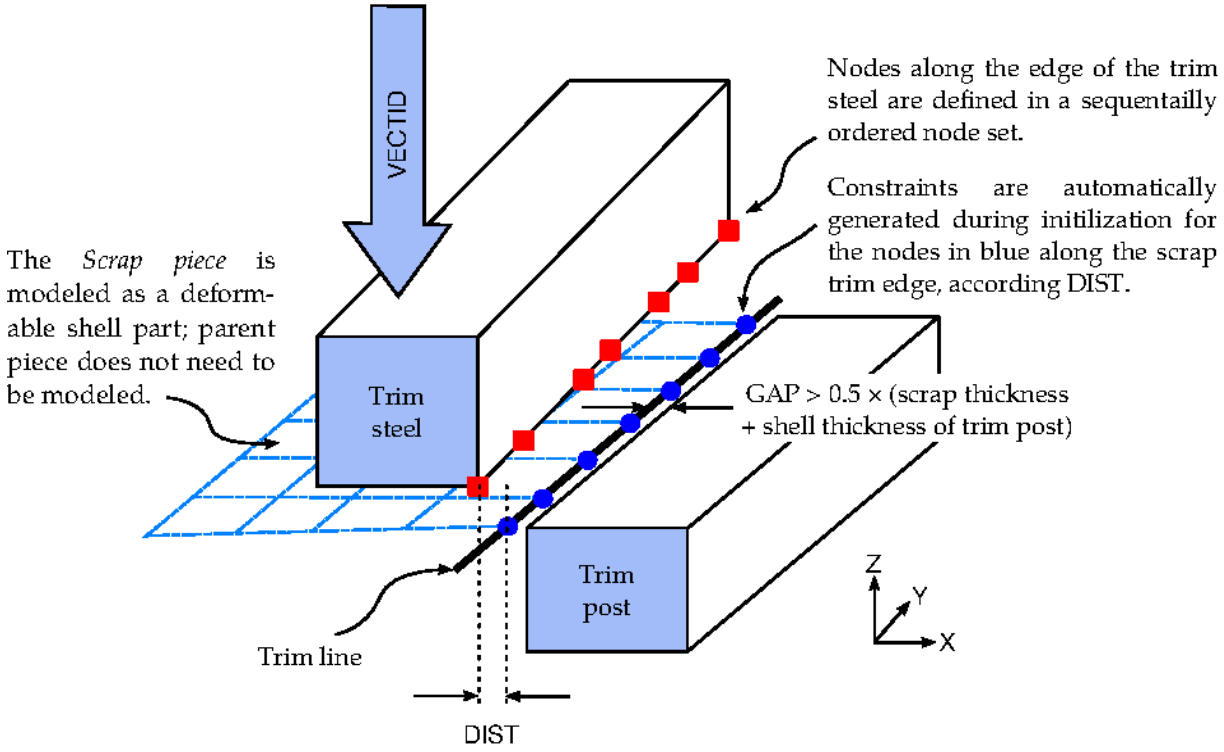

Figure 0-1. Modeling details of the scrap trimming simulation *(Modified from the original drawing courtesy of the Ford Motor Company).*

Background:

Sheet metal trimming and the resulting scrap fall are top factors in affecting the efficiency of stamping plants worldwide. Difficult trimming conditions, such as those multiple direct trims, a mixture of direct and cam trims, multiple cam trims involving bypass condition, can cause trimmed scraps to get stuck around and never separate from the trim edge of the upper trim steels or lower trim post. Inappropriate design of die structure and scrap chute can slow down or prevent scraps from tumbling out to the scrap collectors. Smaller scrap pieces (especially aluminum) could sometimes shoot straight up, get stuck and gather in parts of the die structure. All these problems result in shutdowns of stamping presses, reducing stroke-per-minute (SPM) and causing hundreds of thousands of dollars in lost productivity. With the help of this keyword, engineers can examine in the virtual world the trim detail, manage scrap energy, study different trimming sequences, explore better die structure and scrap chutes design and layout, etc. This feature is developed in conjunction with the *Ford Motor Company*.

Description of the Model:

As shown in Figure **0-1**, the scrap piece is modeled as a deformable body and the trim steel and trim post as rigid shell elements, while the parent piece does not need to be modeled at all. Between the trim edge of the scrap piece and the post there should be a gap (indicated by GAP in the figure). The gap ensures that the contact interface (to be explained later) correctly accounts for the shell thickness

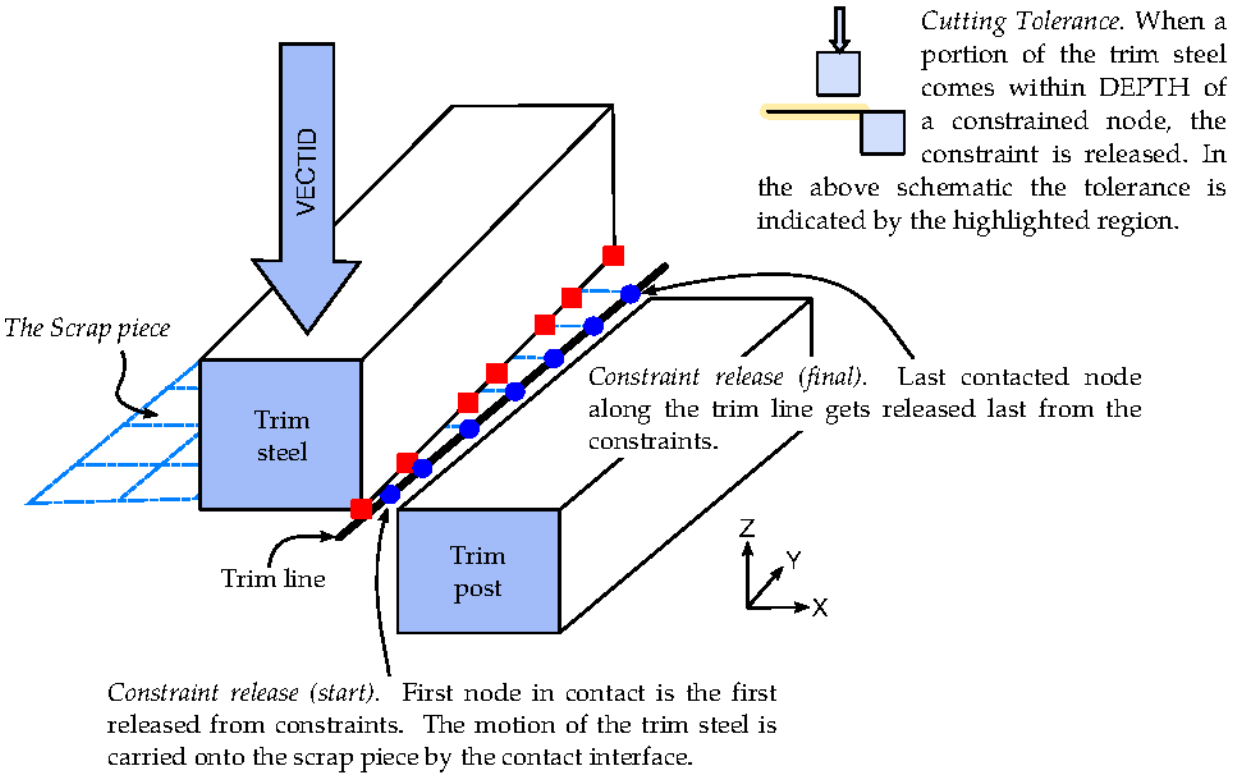

Figure 0-2. Contact-based separation and contact-driven kinematics and dynamics *(Modified from the original drawing courtesy of the Ford Motor Company).*

along the edge. A gap that is too small may cause initial penetration between the scrap and the post which may manifest as unphysical adhesion between the scrap and the post.

The edge of scrap piece should be initially flush with that of the trim post (perpendicular to the trim direction), just as exactly what happens in the production environment. If the scrap is unrealistically positioned above the trim post edge, the scrap may be permanently caught between the trim steel and the post under a combination of uncertain trimming forces as the trim steel moves down.

During initialization, constraints are added automatically on the nodes along the scrap trim edge corresponding to the node set along the trim steel, based on the supplied tolerance variable DIST and trim vector VECTID. The node set must be arranged so that the nodes are in sequential order (*LS-PrePost 4.0* creating node set by *path*). The direction of the path is not important. As the edge of the trim steel comes within DEPTH distance of the trim line the constraints are removed. The contact interfaces serve to project the motion of the trim steel onto the scrap piece, see Figure **0-2**.

Parameters:

1. The value of DEPTH is typically set to one-half of the scrap thickness.
2. The initial gap separating the scrap from the post must be greater than the average of the scrap and post thickness values.

3. The input parameter DIST should be set larger than the maximum distance between nodes along the trim steel edge and scrap edge the trim direction (use an *LS-PrePost* view normal to the trim direction).
4. A very small SLSFAC (0.001~0.01) is recommended in the *CONTROL_CONTACT keyword.

Contact:

Only *CONTACT_FORMING contact interfaces are allowed for contact between the scrap piece and the trim steel. In particular, *CONTACT_FORMING_SURFACE_TO_SURFACE is recommended. A negative contact offset must be used, and this is done typically by setting the variable MST in *CONTACT_FORMING_SURFACE_TO_SURFACE to the negative thickness value of the scrap piece.

For contact between the scrap piece and the shell elements in all the other die structures, *CONTACT_AUTOMATIC_GENERAL should be used for the edge-to-edge contact frequently encountered during the fall of the scrap piece. All friction coefficients should be small. The explicit time integrator is recommended for the modeling of scrap trim and fall. Mass scaling is not recommended

LS-PrePost:

The node set defined along the trim steel edge can be created with *LS-PrePost 4.0*, via *Model/CreEnt/Cre, Set Data, *SET_NODE, ByPath*, then select nodes along the trim edge continuously until finish and then hit *Apply*.

Keyword examples:

A partial example of using the keyword below includes a node set ID 9991 along the trim steel (PID 2) edge used to release the constraints between the scrap piece with PID 1, and the parent piece. The LCID for the trim steel kinematics is (+)33 (load curve is controlled by velocity) moving in –Z direction. The trimming velocity is defined as 1000 mm/s and the retracting velocity is 4000 mm/s. The variables DEPTH and DIST are set to 0.01 and 2.5, respectively. The contact interface between the trim steel and scrap piece is defined using *CONTACT_FORMING_SURFACE_TO_ SURFACE and contact between the scrap and all other die structures are defined using *CONTACT_AUTOMATIC_GENERAL.

```
*KEYWORD
*CONTROL_TERMINATION
&endtime
*CONTROL_FORMING_SCRAP_FALL
$       PID     VECTID      NDSET       LCID      DEPTH       DIST
          1                  9991         33       0.75       2.0
*SET_NODE_LIST
       9991
      24592      24591      24590      24589      24593      24594      24595      24596
*BOUNDARY_PRESCRIBED_MOTION_rigid
```

```
$pid,dof,vad,lcid,sf,vid,dt,bt
2,3,0,33,-1.0
*DEFINE_CURVE
33
0.0,0.0
0.216,1000.0
0.31,-4000.0
0.32,0.0
0.5,0.0
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
*CONTACT_forming_surface_to_surface_ID
         1
         1         2         3         3         0         0         0         0
      0.02       0.0       0.0       0.0      20.0         0       0.01.0000E+20
$#     sfs       sfm       sst       mst      sfst      sfmt       fsf       vsf
       0.0       0.0       0.0      &mst       1.0       1.0       1.0       1.0
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
*CONTACT_AUTOMATIC_GENERAL_ID
         2

*END
```

For the negative option of LCID, displacement will be used as input to control the tool kinematics. A partial example is provided below, where LCID is defined as a negative integer of a load curve, controlling the trim steel kinematics. The trim steel is moving down for 27.6075 mm in 0.2 sec to trim, and moving up for the same distance to its original position in 0.3 sec to retract. Although this option is easier to use, the corresponding velocity from the input time and displacement must be realistic for a realistic simulation.

```
*CONTROL_FORMING_SCRAP_FALL
$ LCID<0: trimming steel kinematics is controlled by displacement.
$       PID     VECTID      NDSET       LCID      DEPTH       DIST
          1         44          1     -33332       0.70       2.00
*DEFINE_VECTOR
44,587.5,422.093,733.083,471.104,380.456,681.412
*BOUNDARY_PRESCRIBED_MOTION_rigid_LOCAL
$pid,dof,vad,lcid,sf,vid,dt,bt
11,3,2,33332,1.0,44
*DEFINE_CURVE
33332
0.0,0.0
0.2,-27.6075
0.5,0.0
```

Revision information:

This feature is available starting in LS-DYNA Revision 63618. The latest revision provides enhanced capabilities. A graphics user interface capable of setting up a complete input deck is now available in *LS-PrePost4.0* under *APPLICATION/Scrap Trim* (http://ftp.lstc.com/anonymous/outgoing/lsprepost/4.0/metalforming/), pending the ending of an exclusive period. A reference paper regarding the development and application of this keyword can also be found in the *proceedings of the 12th International LS-DYNA User's Conference*.