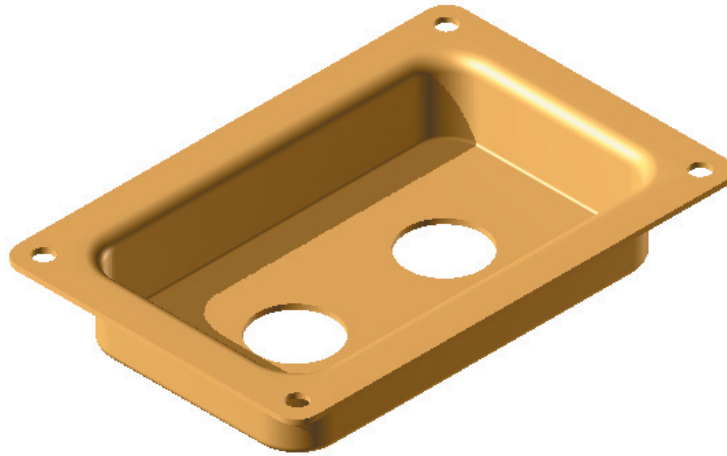# Deep Drawing Analysis

When a cup or box shaped part is produced from sheet metal, one possible processing alternative is deep drawing. In this tutorial, we will examine the deep drawn part shown below. This part has also been analyzed in the **deep drawn part** sample file installed with the software.

Part description

1. Start a new analysis in DFM Concurrent Costing.

2. Enter **drawn part** for the *Part name* in the group box. Accept the default value for *Life volume* of 100,000. Choose the Hollow block envelope shape and enter dimensions as shown below. Also note the forming direction chosen.
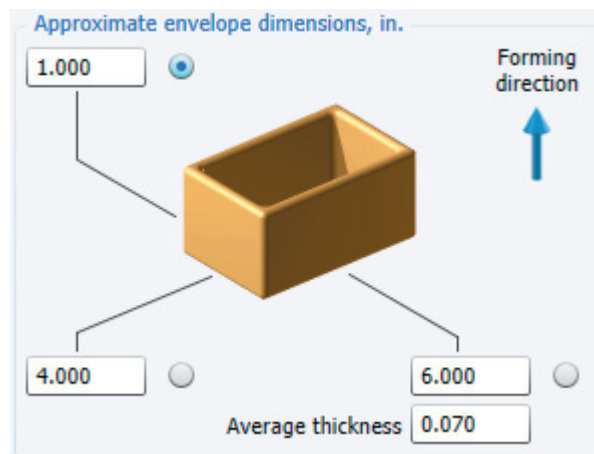
3. With this data entered, click the **Select process and material** button.

4. Choose the *Separate operations* process in the S*heet metal deep drawing* category. Open the *Carbon steel* category and click the *Generic low carbon steel* material. Green indicators are shown for the process and material chosen which means the combination presents no practical limitations. Click the **OK** button on the dialog to accept the choices and return to the main window.

5. The *Separate operations drawing process* entry is now highlighted on the Process Chart. The default information in the Response Panel on the right has been automatically generated based upon the data entered so far and information contained in the software's Machine and Material libraries. This default information will now be refined in order to generate a more accurate cost estimate.

6. We accept the default information in the *Basic data* group box. In the *Part basic data* group box, edit the base length and width as well as the corner, bottom, and flange radii as shown below.

7. Click the **Calculate** button in the *Cost results* box, to update the estimate.

8. You may wish to save this file for later viewing. Choose *Save* from the *File* menu, and supply a file name.

9. Accept the default information in the *Operation data* group box. In the *Additional setups* group box, enter **1** for the *Hole punching* response, as shown below.

10. Click **Calculate** to add the hole punching setup to the Process Chart.

11. The remaining Responses Panel group boxes are used for definition of the part's geometry. This information can either be entered directly into these responses or the software's Geometry Calculator can be used as shown in the following section.

Completing part geometry data

1. To specify the part geometry data, click the 🖩 next to the Volume as drawn and trimmed field to open the Geometry Calculator.

2. We will approximate the volume of the part, excluding the holes, by defining the flange and box portions of the part separately. For the flange, click the Block button to add a block entry to the geometry chart. Rename the *block* entry **flange**.

3. Press tab and enter a flange thickness of 0.07 inches, a flange width of **0.5** inches and a total flange length of **18** inches.

4. Add a Box entry to the geometry chart. Enter a height of **0.93** inches, a width of **3** inches, a length of **5** inches, and a Wall thickness of **0.07** inches.

5. In the totals below the chart, the part's *Volume as drawn and trimmed* is 2.626 cubic inches. Click **OK** to close this Geometry Calculator.

6. Click the ▦ next to the Trim perimeter field. Add two of the *Line - length specified* elements. Without renaming the entries, enter a length of **6** inches for one and a length of **4** inches for the other. Change the repeat count of both entries to **2**. Note the *Trim perimeter* totals 20 inches. Click **OK**.

7. Click the ▦ next to Number of holes to define the two large holes and four small holes punched in the part. Click the circular hole on the toolbar to add a round hole to the geometry chart. Enter a hole diameter of **1** inch and change the hole's repeat count to **2**. Add another round hole to the geometry chart, change its repeat count to **4,** and enter a diameter of **0.25** inches.

8. Note the software has calculated the following totals.

⌄ Punch holes 1		
Number of holes	6	☑
Area of holes, in²	1.767	☑
Perimeter of holes, in.	9.425	☑

9. The geometry definition is now complete. Click **OK** to close the Geometry Calculator.

10. Click **Calculate** to update the cost results and note that the total cost of the part is $1.45.

⌄ Cost results, $	Previous	Current
material	0.4984	0.4348
setup	0.0259	0.0293
process	0.5393	0.6217
rejects	0.0223	0.0258
piece part	1.0858	1.1116
tooling	0.2999	0.3392
total	1.3858	1.4508
Tooling investment	29,993	33,921

Combining operations

In some cases, operations performed on two separate setups can be combined so they are done in a single compound tool on a single setup. Combining operations normally increases the cost of tools while decreasing the cost for processing. The software will quantify this increase and decrease in costs and help you determine if combining operations is worthwhile in terms of the total cost of the part.

After considering the possibility of combining various operations listed on the process chart, we can see two possibilities for combining. Hole punching could be carried out during the flange trim operation using a trim tool that incorporates punches to create the holes during trimming. The two restrike operations could also be combined using a tool that would shape the flange and bottom radii simultaneously. These possibilities will now be investigated to determine if combining these operations will result in a lower part cost overall.

1. Click the *Punch holes 1* operation on the Process Chart. In the Responses Panel you see the *Process combination* group box as shown below.
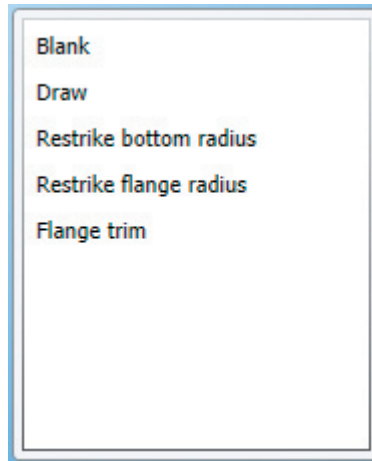
Operation result	
Operation time per part, s	2.00

Process combination
Combine operations

2. Click the **Combine operations** button and you are shown a list of operations that could conceivably be combined with the punch holes operation.

Blank

Draw

Restrike bottom radius

Restrike flange radius

Flange trim

3. Select the *Flange trim* operation and click **OK** to close the dialog. The punch holes and flange trim setups are replaced with a single setup and a compound operation.

4. Highlight the top-level entry on the Process Chart, labeled *Generic low carbon steel sheet metal part*. In the *Cost results* pane, notice that the total cost per part has decreased from $1.45 to $1.38. This indicates combining operations is beneficial in this case because the overall cost per part has decreased.

5. Click the *Restrike flange radius* operation on the Process Chart and click the **Combine operations** button on its Responses Panel. Select the *Restrike bottom radius* operation from the Combine operations dialog and click **OK**.

6. Highlight the top-level entry on the Process Chart and notice that the total cost per part has decreased from $1.38 to $1.36 as shown below. Combining operations is also beneficial in this case.

Cost results, $

	Previous	Current
material	0.4348	0.4348
setup	0.0259	0.0211
process	0.5309	0.4591
rejects	0.0206	0.0161
piece part	1.0122	0.9312
tooling	0.3681	0.4251
total	1.3803	1.3563
Tooling investment	36,812	42,512

Comparing to another process

The design of a manufactured part depends on the material and process used to make it. For this reason, during early stages of product development, it is useful to economically compare various strategies for manufacturing parts. A part which is stamped and bent from sheet metal may serve the same function as the drawn part, possibly at lower cost. This possibility will now be economically investigated.

1. Right-click the Original analysis tab and select *Copy* right-click again and select *Paste*. A copy of the deep drawing analysis is made and placed on a new tab. Rename the tab **Compound die.**

2. Click the **Select process and material** button to open the selection dialog. Choose *Compound die* from the *Sheet metal stamping* category; and select the *Generic low carbon steel* material from the *Carbon steel* category.

3. Click the **OK** button. Click **Yes** when the 'Switching processes will delete the data that does not apply to the new process' warning appears. A new Process Chart is created and the data entered into the drawing analysis has been copied to the new stamping analysis.
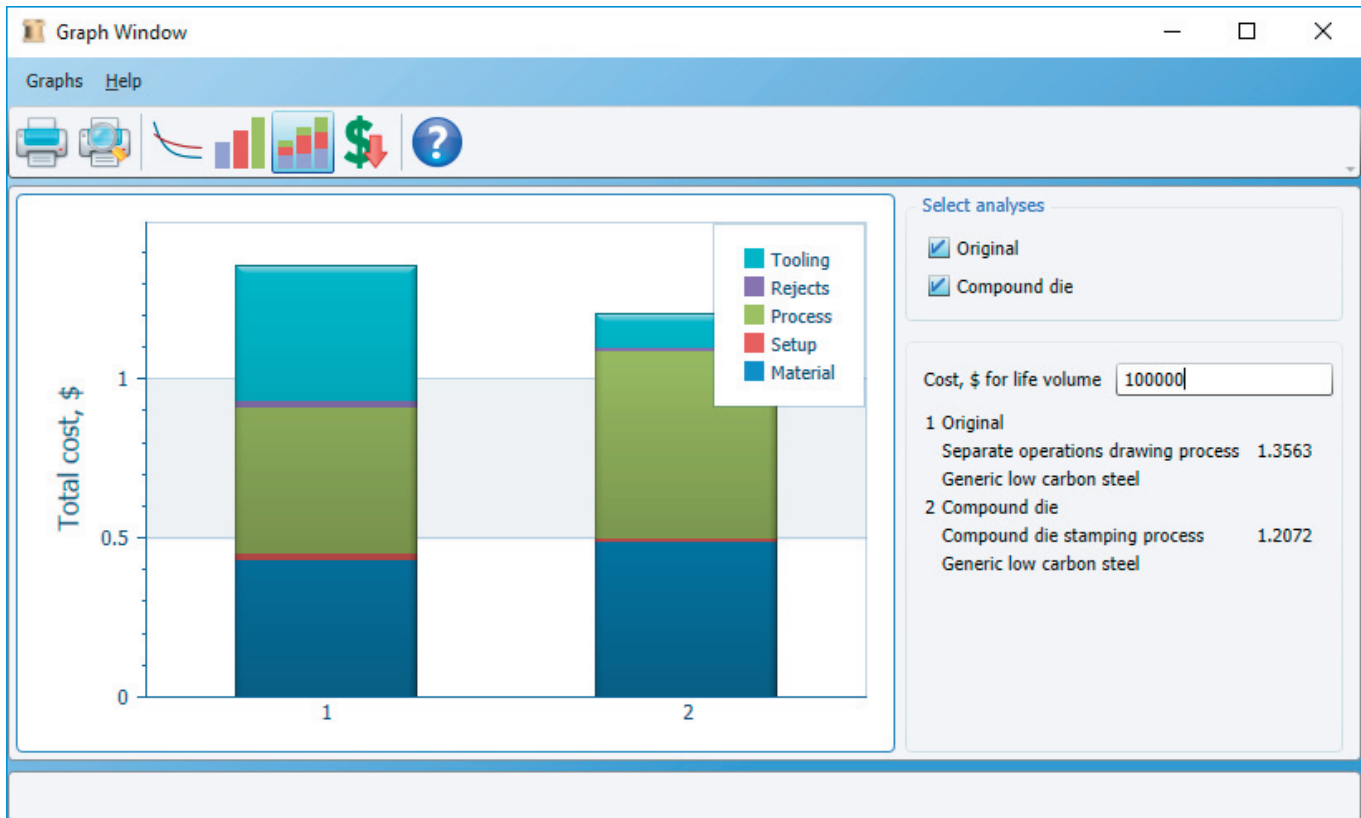
4. Much of the data imported from the drawing analysis is placed in the *Compound die operation data* group box. Data that has been imported, or calculated based upon imported information, are shown in responses with a gold background.

Compound die operation data	
Area of blank, in²	37.519
Perimeter of blank, in.	28.000
Number of holes	6
Area of holes, in²	1.767
Perimeter of holes, in.	9.425
Number of form features	0
Perimeter of form features, in.	0.000

5. The *Perimeter of blank* was not specified in the drawing analysis so that information has not been imported. The default value of 28 inches, which is estimated from the part's envelope shape and dimensions, is very close to the perimeter sheared on the box. For this reason we will accept this default value and continue with our analysis.

6. The stamped part will require eight bends to form the box and flange. These bends will all be made on a single press brake. Enter **1** into the *Press brake* response in the *Additional setups* box to add the press brake. Click **Calculate** to update the Process Chart.

7. Enter **8** in the number of bends response in the *Press brake 1* group box. Four of these bends are each 3 inches long and the remaining four of these bends are each 5 inches long. Enter this total of **32** inches into the *Length of bend lines* response as shown below.

Press brake 1 data	
Number of bends	8
Length of bend lines, in.	32.000

8. Click **Calculate** to update the cost results.

9. Click *Cost Totals Stacked Bar Chart* in the *Results* menu to make a graphical cost comparison of the stamped and drawn parts. In the Select Analyses group box, select both analyses.

Graph Window   — ☐ ✕

Graphs   Help

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Select analyses

☑ Original

☑ Compound die

Cost, $ for life volume 100000

Legend:
- Tooling
- Rejects
- Process
- Setup
- Material

1 Original
   Separate operations drawing process   1.3563
   Generic low carbon steel
2 Compound die
   Compound die stamping process   1.2072
   Generic low carbon steel

(Y-axis: Total cost, $ — values 0, 0.5, 1; X-axis: 1, 2)

10. This graph shows the drawn part costs $1.36 while the stamped part costs $1.21 for an overall cost savings of 15 cents with the stamped part. The stamped part also requires just about one quarter the upfront investment in dedicated tooling.

However, the stamped part has open corners that are not as aesthetically pleasing as the closed and rounded corners on the drawn part. In addition, the small holes on the flange of the drawn part would probably have to be relocated to the center of each bent lip on the stamped part. If these characteristics of the stamped part meet design objectives, a cost savings of about 15 percent can be realized by going with the stamped part.