Die Design Software and Simulation Technology Experience

A Proposed Method for Ranking Progressive Die Strips

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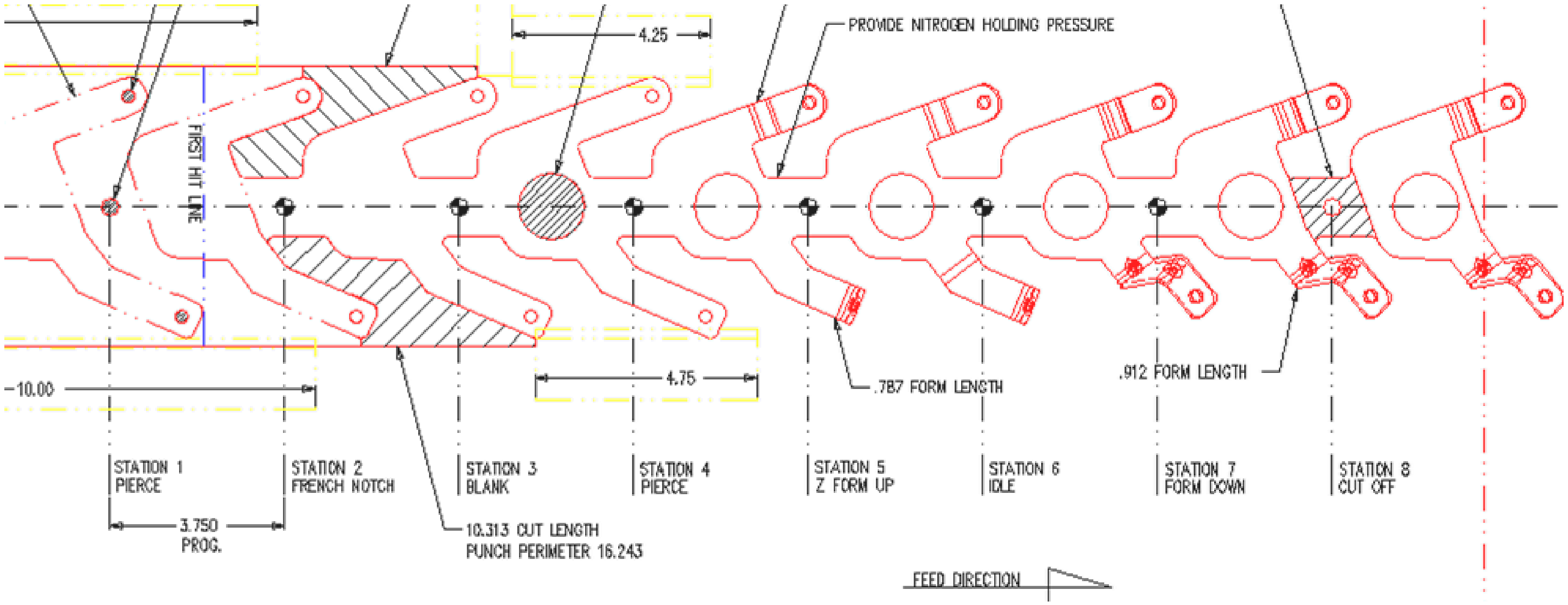
Processing the Part
Creating the Strip Layout



CREATING THE STRIP LAYOUT

A Strip Evaluation Ranking Method

From *MetalForming Magazine,* **Tooling By Design**, Sept 2012 to Nov. 2012

Adapted from Alan C. Lin and Dean K. Sheu, *Knowledge-Based Sequence Planning of Shearing Operations in Progressive Dies*, International Journal of Production Research, 2010

In order to choose the best strip layout from the several possible strips, each layout must be compared and ranked on a relevant scoring system. Among many factors that influence the cost and quality of a progressive die, four factors are of prime concern:

- Station number factor, *Fn*
- Moment balancing factor, *Fb*
- Strip stability factor, *Fs*
- Feed height factor, *Fh*

3

A Strip Evaluation Ranking Method

An evaluation score (*Ev)* can then computed based on these four factors and their corresponding weighting factors:

$$Ev = (wn \times Fn) + (wb \times Fb) + (ws \times Fs) + (wh \times Fh)$$

All four evaluation factors are formulated to range from a total of 10 to 100. A higher score indicates better efficiency in cost and production.

NOTE: The four weighting factors, wn, wb, ws, wh, are chosen by the designer or process engineer who determines how much importance each factor contributes to the strip evaluation.

4

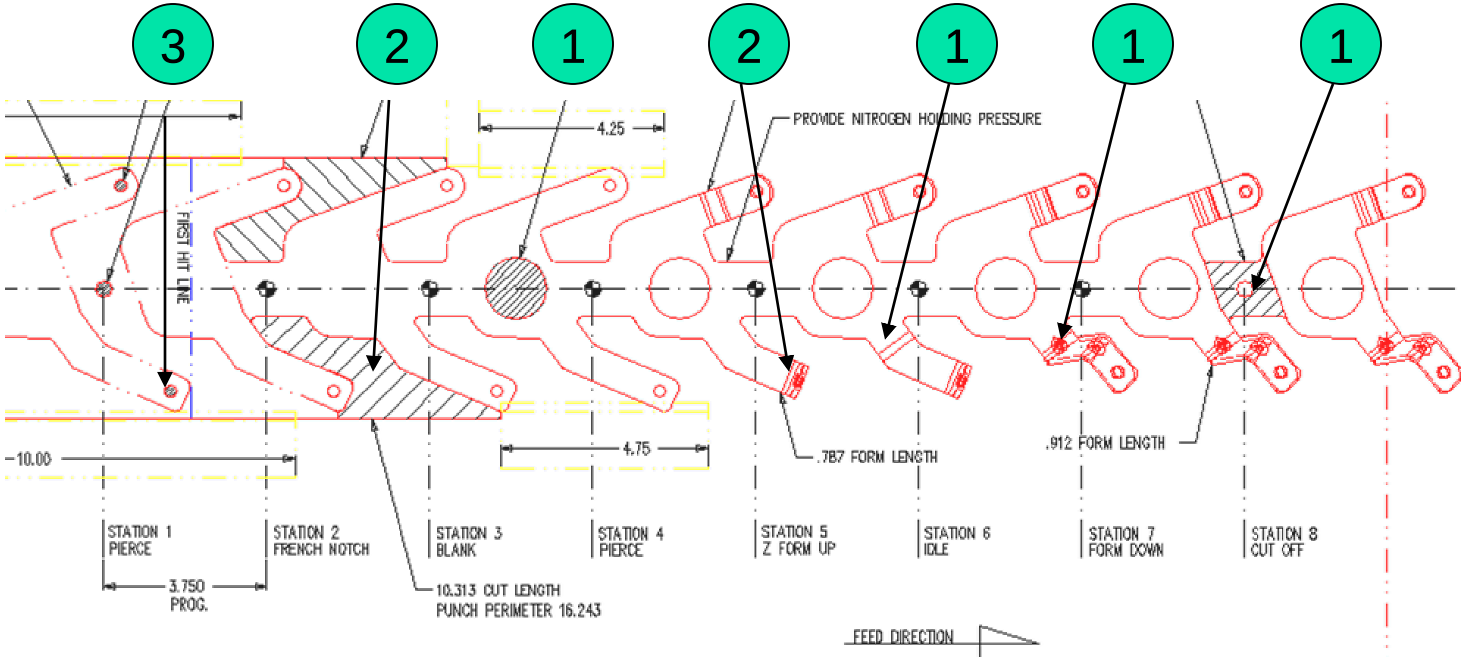
A Strip Evaluation Ranking Method

Station number factor, ***Fn,*** determines how good a strip layout is in terms of the number of stations that it has. The factor has values ranging from 10 to 100.

An Fn value of 100 (best possible) is for a minimum number of stations, or two stations total. In contrast that value becomes 10 for the maximum number of stations, usually the total number of punches for cutting and bending in the proposed strip.

5

A Strip Evaluation Ranking Method



2 stations, Fn = 100

11 stations, Fn = 10

From *MetalForming Magazine,* Tooling By Design, P. Ulintz, Sept 2012 to Nov. 2012

6

A Strip Evaluation Ranking Method

The station number factor can be formulated by means of the following equation:

$$F_n = 100 - 90 \times \frac{N - N_{min}}{N_{max} - N_{min}} \qquad \frac{7 - 2 = 5}{11 - 2 = 9}$$

$$F_n = 100 - (90 \times 5/9) = 50$$

N = total number of stations in the strip layout
Nmax = total number of punches (cutting and bending)
Nmin = the possible minimum number of stations, *Nmin* = 2

7

A Strip Evaluation Ranking Method

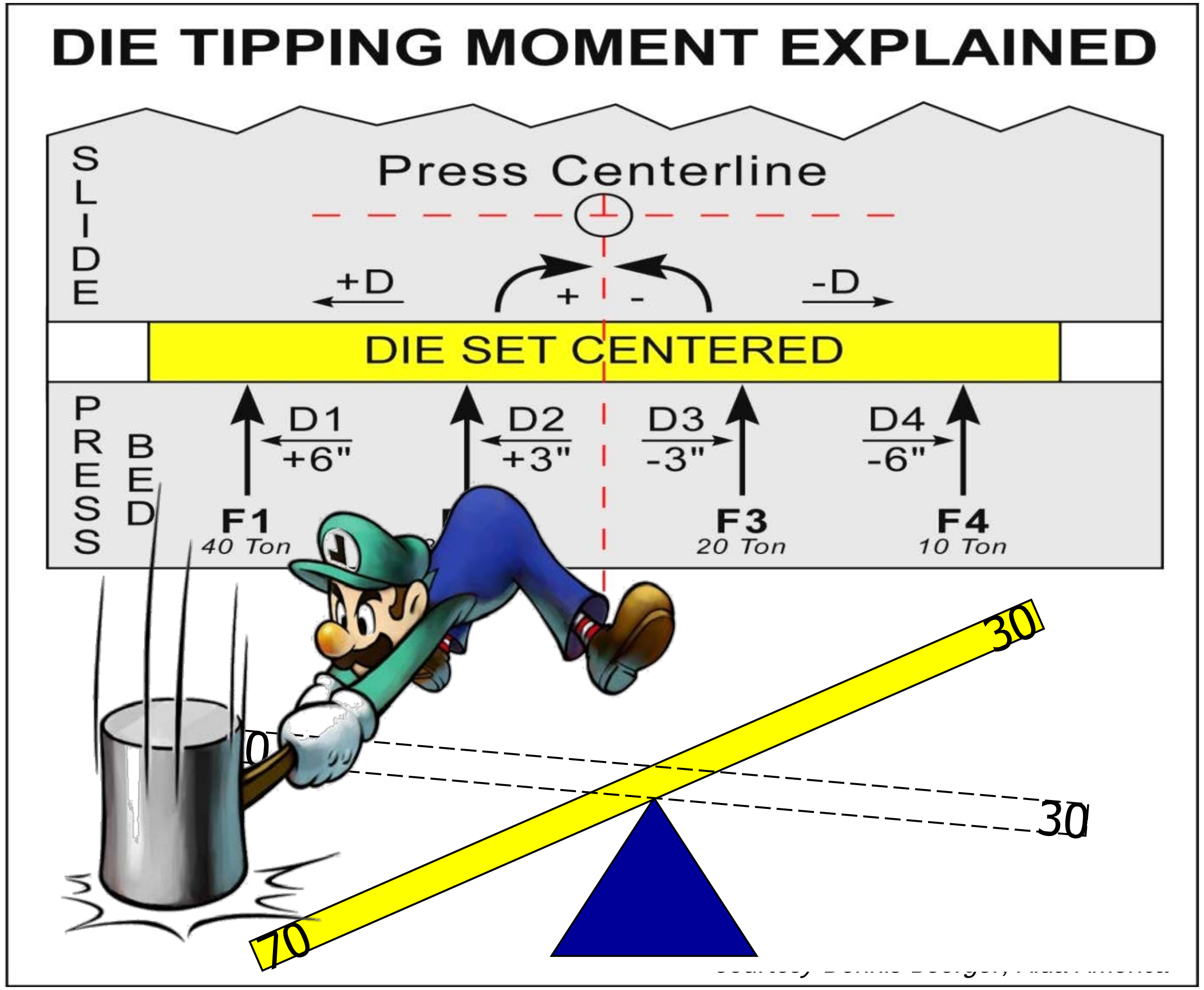
When two or more die stations are performing their task on the die strip, the forces are simultaneously acting on the strip at different points.

If the reaction forces are unbalanced relative to the press center line, ram tipping occurs. Since the center of the die is usually placed under the center of the ram, tipping moment severity must be considered in strip layouts.

Thus, a **moment balancing factor,** ***Fb*****,** is required

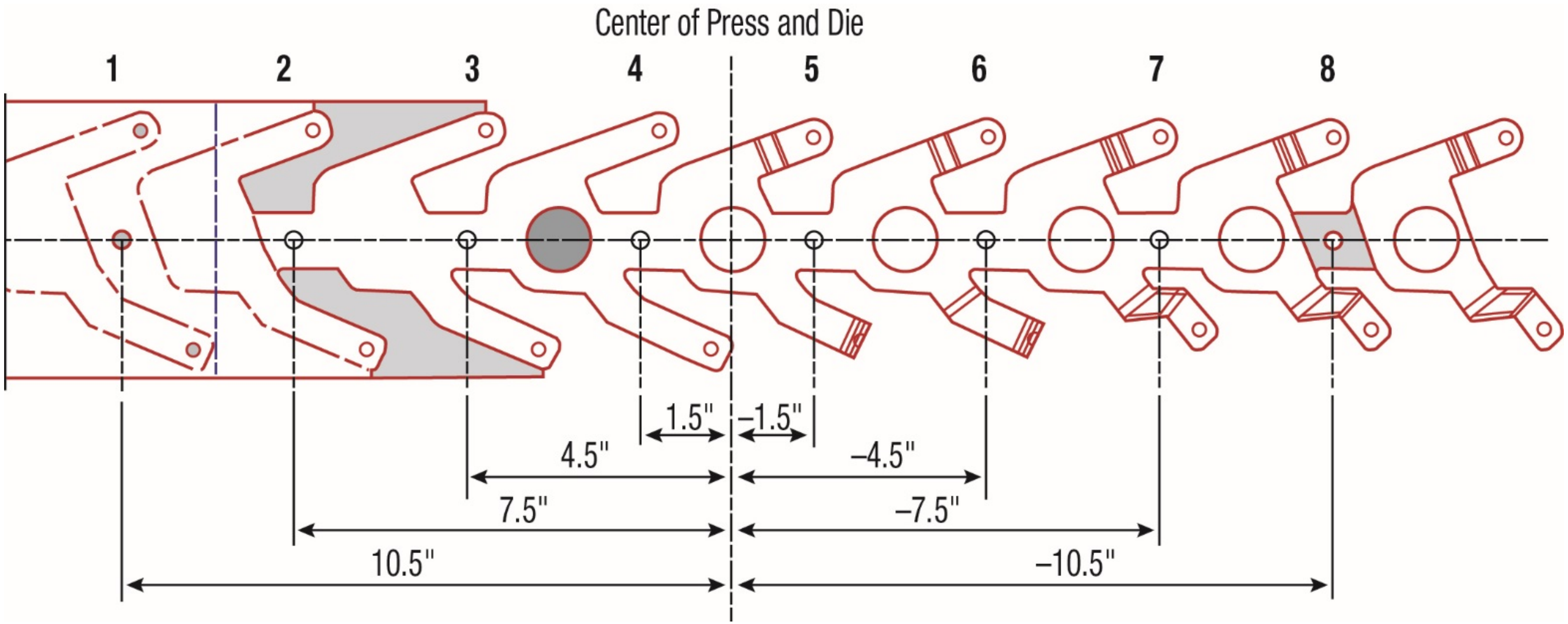
8

Slide Tipping:
Moment Arm Calculations



9

Slide Tipping:
Moment Arm Calculations



Slide Tipping:
Moment Arm Calculations

Tipping Moments as Currently Processed

Station No	Tonnage	Inches from Center	Moment
1	3	10.5	31.5
2	30	7.5	225
3	10	4.5	45
4	10	1.5	15
5	12	-1.5	-18
6	6	-4.5	-27
7	6	-7.5	-45
8	10	-10.5	-105
		TOTAL MOMENT	**121.5**

A positive results indicates center-of-load is left of slide center
Shift load to RIGHT to re-center the load

A Strip Evaluation Ranking Method

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Stamping presses have maximum tipping moments established by the press machine builder. This rating can used to establish a maximum off-center loading parameter: D_{max}

The moment balancing factor can then be calculated by:

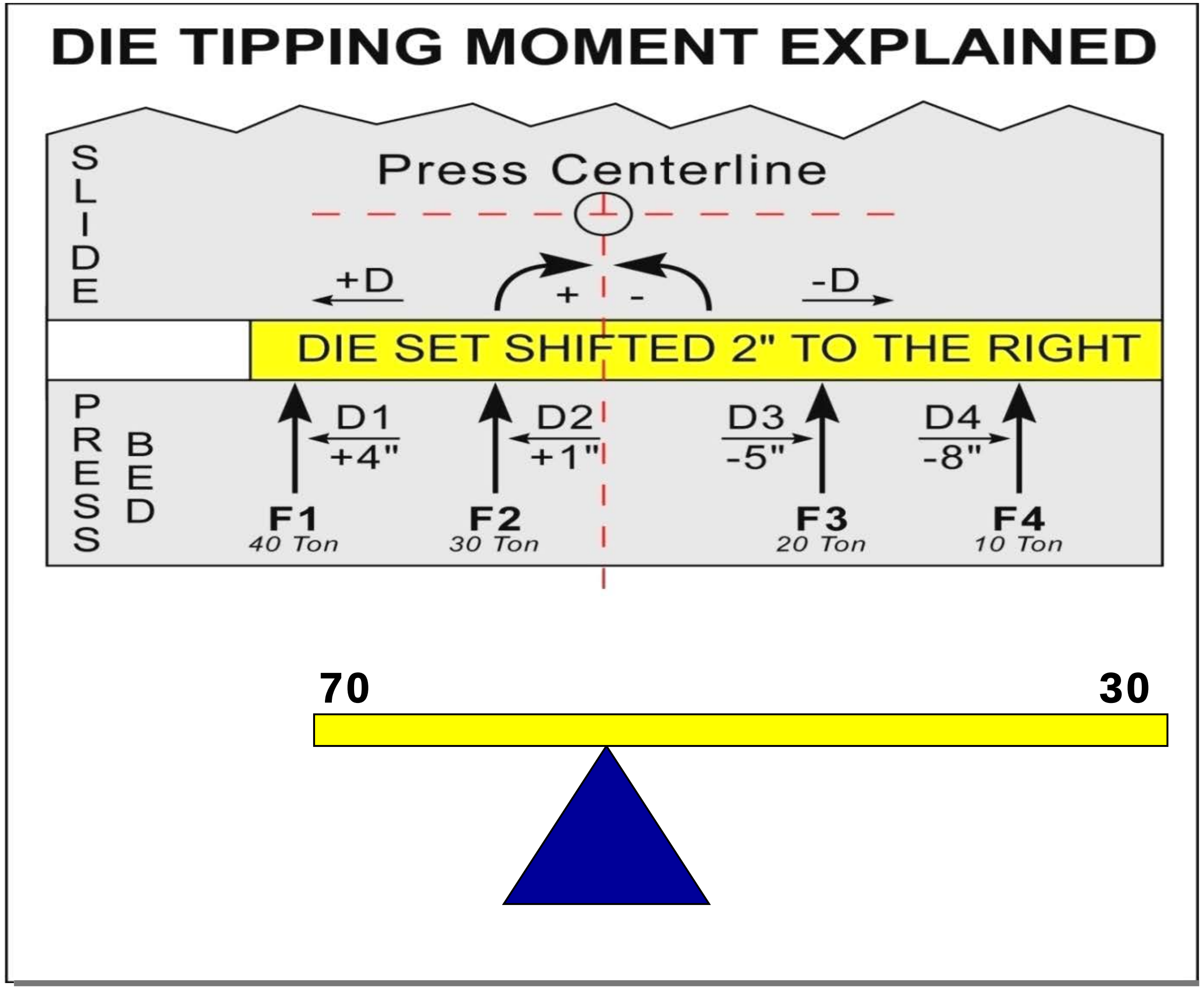
$$F_b = 100 - 90 \times \frac{d}{D_{max}} \qquad \frac{122}{200}$$

$$F_b = 100 - (90 \times 122/200) = 45.1$$

When d = 0, the center of the ram and the center of the stamping loads are completely matched, so the factor Fb = 100 (best condition). When d $\geq$ Dmax, the deviation is so serious that it makes Fb = 10 (worst condition).

12

Slide Tipping:
Moment Arm Calculations



13

Slide Tipping:
Moment Arm Calculations

Shift Load 1.5” to Right

Station No	Tonnage	Inches from Center	Moment
1	3	9.0	27
2	30	6.0	180
3	10	3.0	30
4	10	0.0	0
5	12	-3.0	-36
6	6	-6.0	-36
7	6	-9.0	-54
8	10	-12.0	-120
		TOTAL MOMENT	**-9**

A Strip Evaluation Ranking Method

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Stamping presses have maximum tipping moments established by the press machine builder. This rating can used to establish a maximum off-center loading parameter: D_{max}

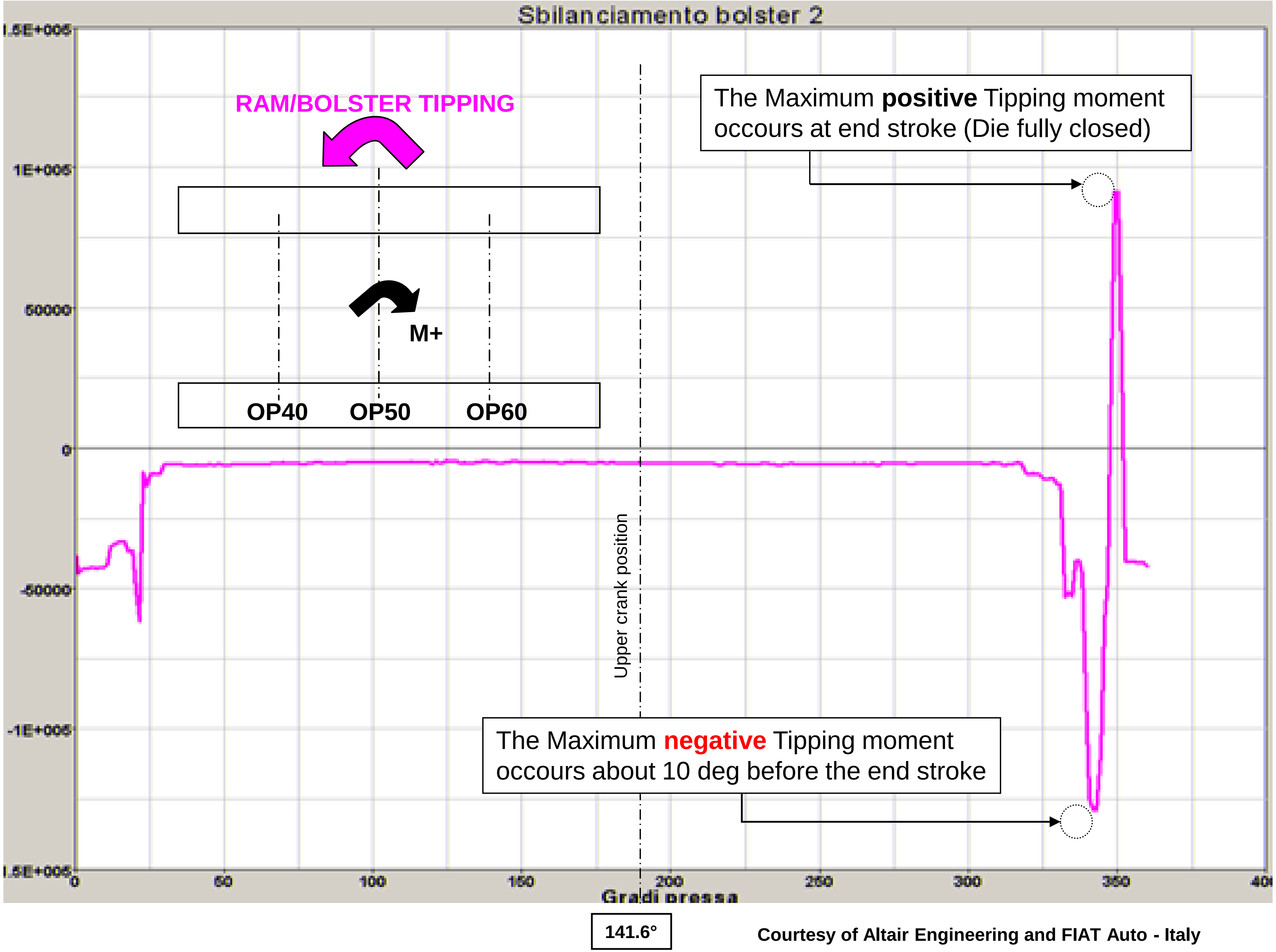
The moment balancing factor can then be calculated by:

$$F_b = 100 - 90 \times \frac{d}{D_{max}} \qquad \frac{9}{200}$$

$$F_b = 100 - (90 \times 9/200) = 95.95$$

When d = 0, the center of the ram and the center of the stamping loads are completely matched, so the factor Fb = 100 (best condition). When d $\geq$ Dmax, the deviation is so serious that it makes Fb = 10 (worst condition).

15



Courtesy of Altair Engineering and FIAT Auto - Italy

A Strip Evaluation Ranking Method

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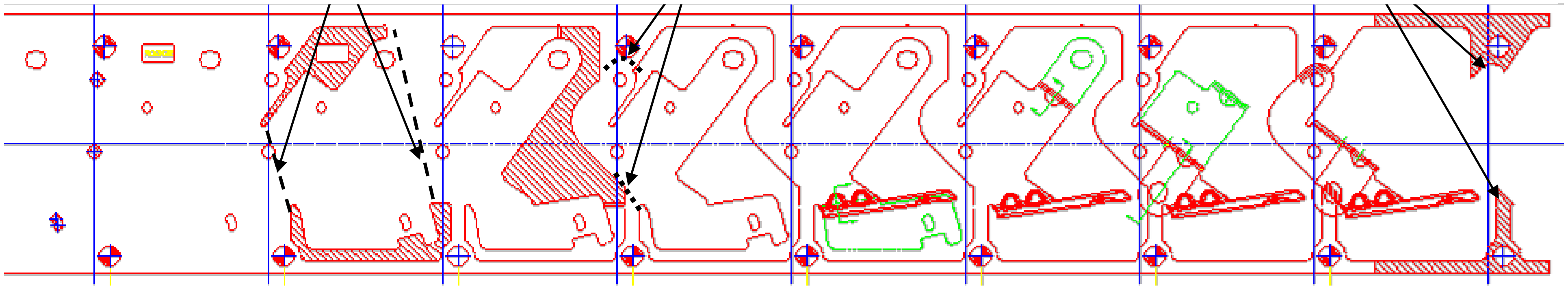
The strip stability factor (*Fs*) determines how reliably the strip feeds in terms of the connecting material that is left to carry the parts as the strip progresses through the die.

$$F_s = 70 \times \{\sum_{k=1}^{N-1} k \times (L_k / L_{Lk})\} / \sum_{k=1}^{N-1} k$$



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A Strip Evaluation Ranking Method

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For ranking purposes, we identify three connection length reductions: optimal, negative, and positive length reductions

Optimal length L_{opt} reduction would provide a stability ranking of 100. This condition seldom exists, but in terms of strip stability it is the best way to process a progressive-die strip. This occurs when the connecting length is reduced linearly with the number of die stations. A 10-station die, for example, would remove 10% of connecting material at each station until a finished part separates from the strip in the final station

A Strip Evaluation Ranking Method

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L_{neg} represents the worst condition, where connecting length is reduced quickly and the blank may become unstable and difficult to feed.

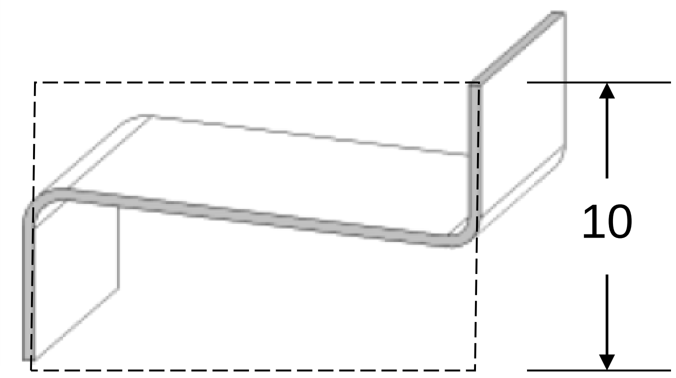
Expect a ranking between 10 and 50 for this type of reduction

L_{pos} is a desirable length reduction. The decreasing trend occurs gently, and part stability of the attached part is optimized. Thus, feeding and blank positioning should have higher accuracy and precision.

A ranking of 50 to 90 would be typical in this case.

A Strip Evaluation Ranking Method

The feed height factor (*Fh*) determines how reliably the strip feeds in terms of the distance that it must lift off the working stations before progressing through the die.



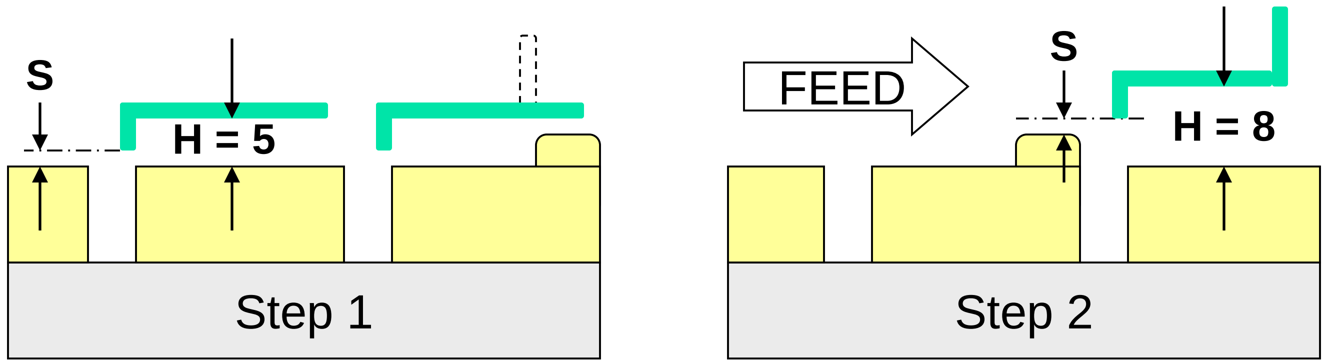
The maximum possible feed height is equal to the height of an imaginary rectangle that encloses the formed part, as shown above, plus the safety factor, S

A Strip Evaluation Ranking Method

For the process illustrated below, the feed height factor is calculated by:

Fh = 100 - 90 x (8-2) / (10-2) = 32.5

The resulting feed height factor is relatively low (100 is best)



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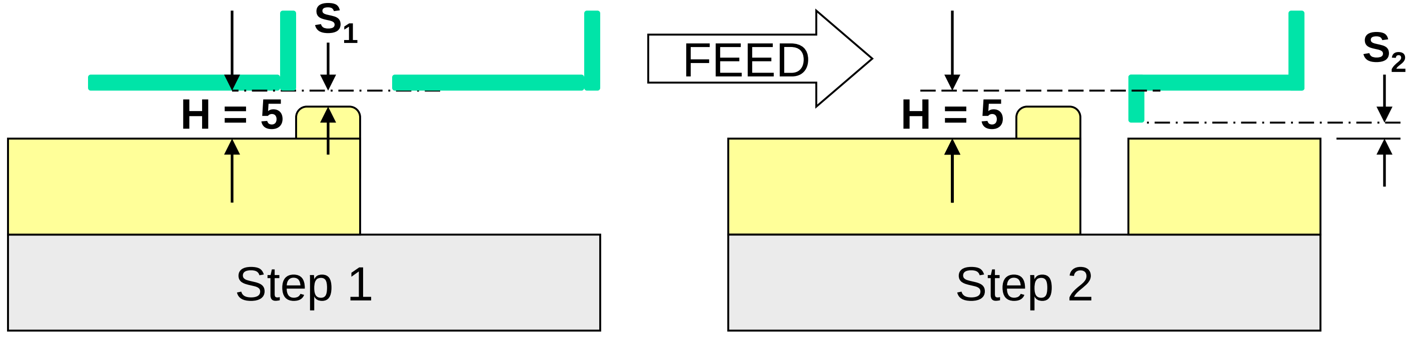
A Strip Evaluation Ranking Method

The feed height factor could be improved by altering the two bending sequence. For this revised process:

$$Fh = 100 - 90 \times (5-2) / (10-2) = 66.25$$



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A Strip Evaluation Ranking Method

All four evaluation factors are then formulated to range from a total of 10 to 100. A higher score indicates better efficiency in cost and production.

$$Ev = (wn \times 50) + (wb \times 45) + (ws \times 53) + (wh \times 66)$$
$$Ev = 214$$

Weighting factors help prioritize each of the four evaluation factors relative to each another so we can better evaluate multiple designs

NOTE: The four weighting factors, wn, wb, ws, wh, are chosen by the designer or process engineer who determines how much importance each factor contributes to the strip evaluation.

A Strip Evaluation Ranking Method

Weighting factors help prioritize each of the four evaluation factors relative to each another:

Ev = (*0.25* x 50) + (*1* x 45) + (*0.50* x 53) + (*0.50* x 66)
Ev = 117

Add one station by splitting the gutting station
Ev = (*0.25* x 40) + (*1* x 37) + (*0.50* x 58) + (*0.50* x 66)
Ev = 109

Add an idle station to better center the die loads, gives:
Ev = (*0.25* x 30) + (*1* x 80) + (*0.50* x 62) + (0.50 x 66)
Ev = 152