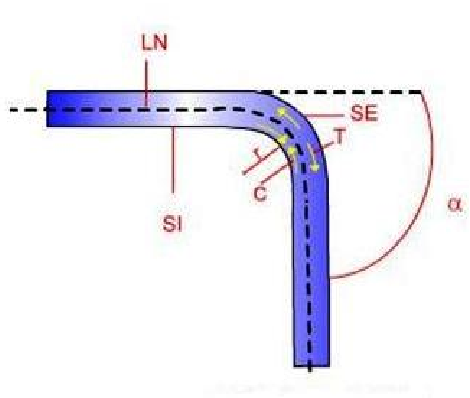
NEUTRAL LINE PERCENTAGE.

The main purpose in elaborating this material is to deal with some difficulties and/or doubts from the metallurgic sector and sheet metal concerning to the conformation of materials through bending or calendering using NLP (Neutral Line Percentage).

There is a region of the part to be bent where deformation does not occur. It neither occurs by traction or compression. It is where the so called neutral line is located and used to calculate bending and calendering operations.

The voltages to which a material is liable to in the bend region decrease from the external faces in direction to the core of the part. As they go in opposite directions, there is a line where these voltages cancel each other . In this way, the neutral line of the bend region does not suffer length changes with the bending. This does not happen on the compressed parts or those with traction. They can increase or reduce their length.



NL: Neutral Line

IS: Internal surface

ES: External surface

r: radius of compliance

C: Compression power

T: traction power.

On the bend phenomenon, the NLP depends on several factors. Among them, the characteristics of the material (hardness), the tool used (taking into account the wearing) and the reason r/e (radius divided by the thickness) pertinent to the geometry of the bend.

Calendering Process:

During the calandragem process the NLP is generally 50%. This is justified through the r/e relation that during this process is always really large because the bends are softer when the radius is considerably larger than the thickness.

Bending Process:

At bending, the situation is different and it becomes more complex because normally the calculated NLP is lower than 50% and it is necessary to take into account, besides the r/e relation, the characteristics of the material and also the conditions of the tools.

So then, how do you determine the NLP on bending?

There are specific methods to determine the Neutral Line Percentage on bending:

- Through the classic literature methods;
- Through the experimental method.

One of the classic methods is shown by Mario Rossi in the book “Stampaggio a Fredo Delle Lamiere” where the author uses the ratio between the internal bend radius (ri) and thickness (e) to determine the NLP:

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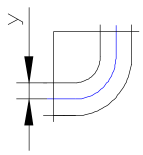
0.2	34.7%
0.5	38.7%
1.0	42.1%
2.0	45.1%
3.0	46.5%
4.0	47.0%
5.0	47.8%
10.0	48.7%
>10.0	aprox. 50.0%

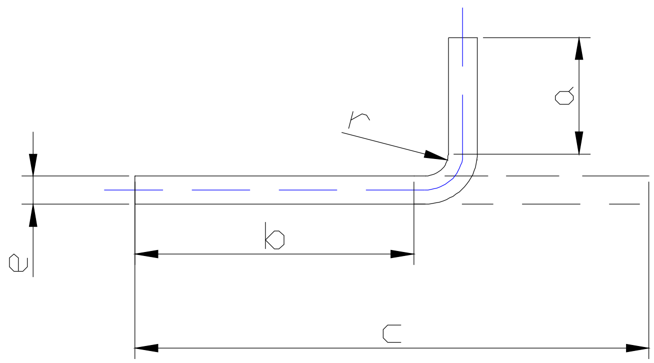
Observe that for small ri/e relations, that is, pointed and extremely forced bends, the NLP is lower (great deformations). It is also possible to see that as the radius increases related to the thickness, the bends become softer and the NLP comes near to 50%.

Experimental method:

On the other hand, the experimental method is not very functional, however, it is more secure because it takes into account the characteristic of the material (hardness) and the condition of the tools (wearing). The experimental method consists of bending a small piece of material of c length (in the thickness, radius and tooling that will be used) and making an inverted calculation to determine the neutral line position (y) related to the thickness. The general formula to determine the distance y (distance between the internal radius and the neutral line), is:

$$y=\frac{c-b-a}{\pi}-r$$





let’s determine the NLP in an experimental example:

Ex.: A test plate cut with a c = 76.2 mm length which has an e = 3.2 mm thickness, was bent with a r = 15.05 mm radius tool. In a random way, when the plate was bent it generated two line segments with measurements a = 19 mm and b = 31.7mm:

Applying the formula and substituting the values we have:

$$y=\frac{c-b-a}{\pi}-r \qquad y=\frac{76,2-19-31,75}{3,14}-15,05$$

$$y=16,21-15,05=1,16$$

Through the ratio of the y distance and the thickness, we have:

$$\frac{y}{e}=\frac{1,16}{3,2} \qquad PLN=0,362$$

Multiplying the result, the value of 36.2% is obtained