# THEORETICAL CONSIDERATIONS ABOUT THE PRECISION INCREASE OF CONICAL DRAWING PIECES

**Lucian V. Severin[1], Traian Lucian Severin[2]**

[1]*University of Suceava, Romania, severin@fim.usv.ro*
[2]*University of Suceava, severin.traian@fim.usv.ro*

**Abstract:** The paper presents same theoretical considerations about the precision increase of conical pieces drawing, among other things the angle calculus work zone of tools. This is influenced by initial dimensions and the initial thickness of the work piece and the size of deformations.

**Keywords**: *conical pieces, precision, drawing, deformations, angle.*

## 1. Introduction.

The process of drawing conical pieces with rigid tools is developing under more difficult conditions compared with the cylindrical parts. In this mode the deformation processing is transmitted from the punch to semi-product through a smaller area with the same degree of deformation and therefore drawing stress have greater values.

Also, in comparison with the cylindrical drawing, the interstice between deformation tools, at the beginning process has great relatively values, what determined taking technological and constructional solutions in technological equipment conceiving, corresponding the relative sheet metal thickness [1].

Comparative analysis of mechanical deformation material scheme shows that these are different in walls pieces (fig.1). Thus, in conical pieces case the stress state is plane and the deformation state is spatial.

The low and middle conical pieces have a little deformation degree of the material and these determined elastically arching when the pieces are removed from the die, particularly at reduced relative thickness of sheet metal. This difficulty is eliminated if use at drawing processes the moulds with special construction (moulds with strong pressing of semi-product by blank-holder moulds with redrawing rib and so on) [1, 2].

Low and middle conical pieces drawing process, with a high precision realized in a single operation, in many situation is needed to be realized the drawing pieces with the dimensional calibration. For that it must angle work zone tool's adequate determination. If these are realized at adequate value from constructive reference material, is not adequate realized the dimensional calibration, or it must great deformation forces by volumetrically calibration of conical piece wall (fig.3).

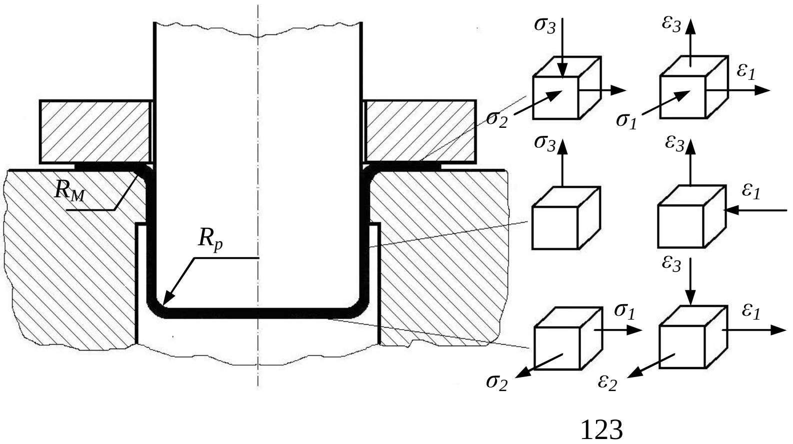



**Figure 1** *Mechanical scheme of cylindrical pieces. drawing.*

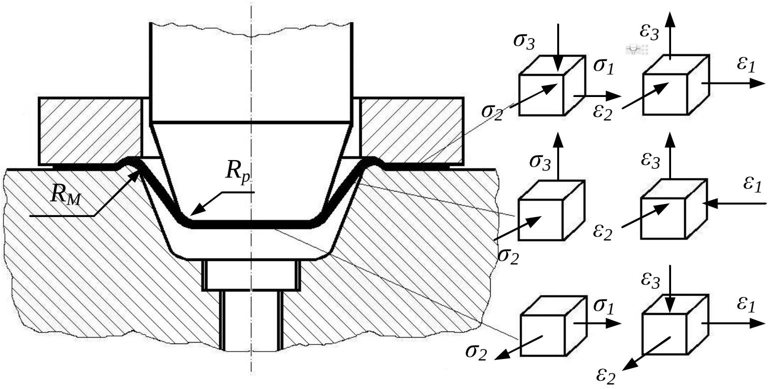



**Figure 2** *Mechanical scheme of conical pieces drawing*

It is not produced a good calibration of piece, because so that is showed by the deformation state of semi-product in upper conical piece wall zone, the thickness increase, from initial semi-product thickness $s_0$, to thickness $s$, at upper conical piece wall.

The question is how to determine the angles work areas of active elements because at the end operation processing calibration track its makeover on entire surface

## 2. Upper piece wall thickness calculus

It is considered a semi-product with the thickness $s_0$ and radius $R_0$ (fig. 4). On this semi-product is considered a point M placed on a circle with radius $\rho$. After conical drawing of semi-product, this point take position $M_1$ on piece wall, at distance $r$ to piece axis, where wall piece thickness is $s_1$

If it is considered a reference system in cylindrical coordinate $(\rho,\theta\ z)$ orientated on the main directions of stress and deformations can be writing:

$$\varepsilon_\theta = ln\frac{r}{\rho} = \varepsilon_2;\ \varepsilon_z = ln\frac{s_1}{s_0} = \varepsilon_3 \qquad (1)$$

where $\varepsilon_\rho$ *şi* $\varepsilon_z$ are the real main deformations in point $M_1$.

Writing Hooke relations between stress and deformations for a plain stress state in this point, and the constance volume relations in plastic deformations, result:

$$\frac{\sigma_\rho}{\sigma_\theta} = \frac{\varepsilon_\rho - \varepsilon_z}{\varepsilon_\rho - \varepsilon_z};\cdots\varepsilon_\rho + \varepsilon_\theta + \varepsilon_z = 0 \qquad (2)$$

If it is note $\frac{\sigma_\rho}{\sigma_\theta} = a$, can be writing:

$$\varepsilon_z = \frac{1+a}{2-a}\varepsilon_\theta \qquad (3)$$

Using relations (1), relation (3) become:

$$ln\frac{s_1}{s_0} = \frac{1+a}{2-a}ln\frac{r}{\rho}$$

With this relation can be calculated the thickness $s_1$ by relation:

$$s_1 = s_0\left(\frac{r}{\rho}\right)^{\frac{1+a}{2-a}} \qquad (4)$$

In upper conical piece wall the thickness $s$ *is* determined with relation (4) where is substituted $\rho$ with $R_0$, $r$ with $R$ and $a$ with zero value, because the stress $\sigma_\rho$ has zero value in point $A$. Therefore it resulted:

$$s = s_0\left(\frac{R}{R_0}\right)^{-\frac{1}{2}} \qquad (5)$$

If note the report $R/R_0$ with $m$, report what defines piece drawing coefficient at the upper wall, relation (5) can be write with relation:

$$s = \frac{s_0}{\sqrt{m}} \qquad (6)$$

Suitable relations (4) along conical wall exist a position of the point $M_1$ where $\varepsilon_z=0$.
This position is obtained if $a=-1$ .Thus can be writing [2]:

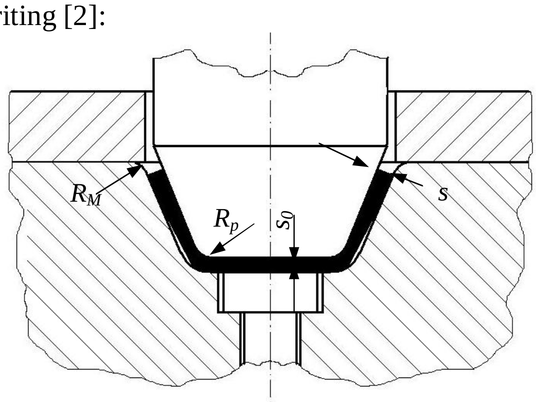
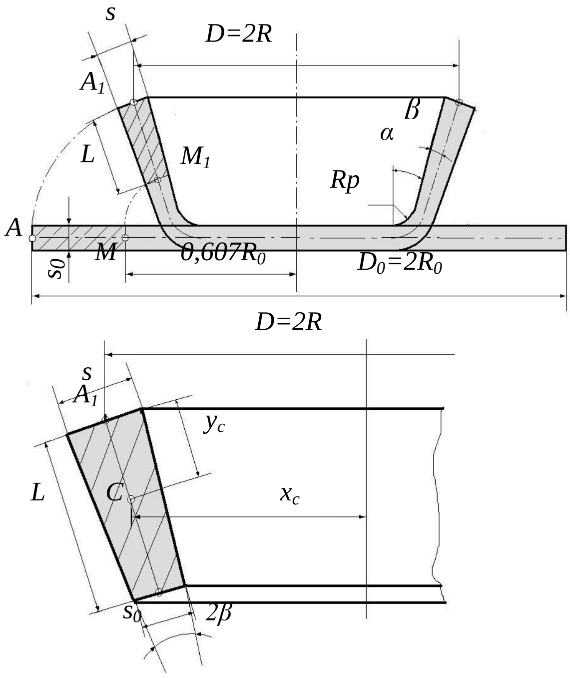



**Figure 3.** *Drawing scheme with piece calibration*



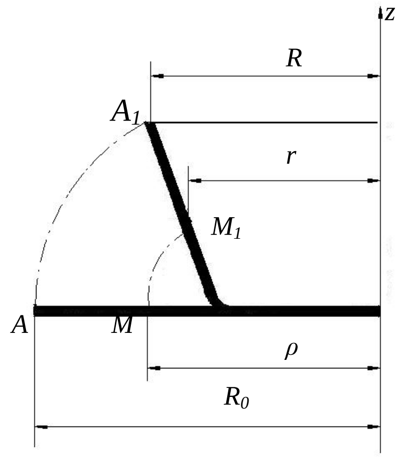




**Figure 4.** *Wall thickness change of drawing conical piece*

$$a=\frac{\sigma_c\, ln\dfrac{R_0}{\rho}}{-\sigma_c\left(1-ln\dfrac{R_0}{\rho}\right)}=-1$$ and by solving is obtained:

$$\rho=\frac{R_0}{\sqrt{e}}=0{,}607\ R_0 \qquad (7)$$

This is the point $M$ position on semi-product what after drawing arrives on piece in the point $M_1$, without the change of material thickness.

**3. Establish the angles of active zone tolls.**

Because of the deformation state described by the relation (4), the thickness conical wall of drawing piece is variable.

The greatest thickness value is calculated by relation (6) and this is in point $A_1$, because the material deformation degree is greatest in this point.

The drawing process with calibration piece dimensions must to be making on the mould with corrected active zone tools with angle $\beta$ (fig.3).

If piece angle $\alpha$ is quoted on middle thickness, then can be writing:

$$\alpha_p=\alpha-\beta \text{ and } \alpha_M=\alpha+\beta \qquad (8)$$

If piece angle $\alpha$ is quoted at piece inside, the work zone tools will have angles:

$$\alpha_p=\alpha \text{ and } \alpha_M=\alpha+2\beta \qquad (9)$$

and it is quoted at piece outside

$$\alpha_p=\alpha-2\beta \text{ and } \alpha_M=\alpha \qquad (10)$$

In relations (8), 9) şi (10) it is noted: piece angle-$\alpha$; punch angle-$\alpha_p$; die angle-$\alpha_M$; angle between inside generatrix of conical surface and the outside generatrix surface -$2\beta$.

Angle size $\beta$ can be established with the position of point $M$ defined by relation (7), tacking account the semi-product thickness is not modified in piece processed. Wall thickness in point $A_1$ is determined by relation (5). If it is noted generatrix length between point $A_1$ and $M_1$ with $L$, can be writing:

$$\beta=arctg\frac{s-s_0}{2L} \qquad (11)$$

where $\beta$ is the angle between conical surface of inside generatrix or conical surface of outside generatrix and middle conical surface generatrix.

The size $L$ can be determinate with relation determined by material volume equality included in plane circular crown with $0{,}393R_0$ width with the material volume included in conical piece wall with middle generatrix by length $L$.

This volume can be calculated with the second Pappus-Guldin theorem, determined with relation [3]:

$$V_p=\frac{s+s_0}{2}L\ 2\pi\, x_c \qquad (12)$$

where, figure 3 corespondly, $x_c$ has the value:

$$x_c = R - y_c \sin\alpha \tag{13}$$

where :

$$y_c = \frac{L}{3}\frac{s + 2s_0}{s + s_0} \tag{14}$$

By $y_c$ substitution in relation (13) with the value determined by relation it is obtained:

$$x_c = R - \frac{L}{3}\frac{s + 2s_0}{s + s_0}\sin\alpha \tag{15}$$

Material volume of semi-product what is processed in piece wall with length $L$ is obtained by relation:

$$V_s = 0{,}632\,\pi\, s_0\, R_0^2 \tag{16}$$

By equalization the relation (12) with (17) and taking account by relation (6) and (15) results:

$$L = \frac{3R_0}{2}\frac{\left(m + m\sqrt{m}\right) - \sqrt{m^2\left(1+\sqrt{m}\right)^2 - 0{,}842\left(\sqrt{m} + 2m\right)\sin\alpha}}{\left(1 + 2\sqrt{m}\right)\sin\alpha} \tag{17}$$

Substituting the length $L$ determined with expression (17) in relation (11)and taking account by relation (6) it is obtained:

$$\beta = arctg\left[\frac{\frac{s_0}{3R_0\sqrt{m}}\left(1-\sqrt{m}\right)\left(1+2\sqrt{m}\right)\sin\alpha}{\left(m + m\sqrt{m}\right) - \sqrt{m^2\left(1+\sqrt{m}\right)^2 - 0{,}842\left(\sqrt{m}+2m\right)\sin\alpha}}\right] \tag{18}$$

With the angle size $\beta$ obtained with relation (18) substituting in relations (8), (9) or (10) and it are determined the work zone tools of the conical piece with calibration drawing.

**4. Conclusions**

The thickening angle of the conical piece drawing wall depend on initial semi-product dimensions used, the initial thickness and drawing coefficient in piece processing determined on greatest diameter of this.

The angle size increases with growth of initial semi-product thickness, with increasing the degree deformation and decreases with increasing semi-product deformed radius at the same degree of deformation and the same initial thickness.

**4. References**

[1] Romanovski, V., P., *Ştanţarea şi matriţarea la rece.* Editua tehnică, Bucureşti, 1970;

[2] Teodorescu, M., Al., *Tehnologia presării la rece.* Editura didactică şi pedagogică, Bucureşti, 1980;

[3] Bachman, K., H., *Mică enciclopedie matematică.* Editura tehnică, Bucureşti, 1980