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RELATIVE SPIRAL FEED DURING ORBITAL DEFORMATION IN THE ANALYSE OF TECHNOLOGICAL PARAMETERS IN ORBITAL DEFORMATION

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Abstract

This paper has been analysed the geometric characteristic of the contact contour between the upper die and the cylindrical workpiece. By means of a computer, the corelation curves of the rate of the cotact area (λ) and the angle subtende by the contact arc (α_{AB}) with respect to the spiral feed (S_θ), rocking angle (θ), and the radius of the workpiece (R) have been drawn. Has been discussed the effect of the relativ spiral feed (S_R) on the configuration of the contact contour and the magnitedes of λ and α_{AB}. Finally, has been presented the minimum relative spiral feed necessary for *full-deformation*.

1.ITRODUCTION

One of the proceedings which increase the sort of products manufactured by cold forming, presenting the major advantage of reducing the manufacturing force, is orbital deformation. This is till nowadays, a Cold Forming Proceeding for metal, used mainly for manufacturing rounded pieces, e.g.: toothed wheel, which represent approximately 80% of forging pieces. The estimation made by International Iron Steel Institute show us that 1% of the pieces manufactured in the whole world it basis on orbital deformation. Main advantages of orbital deformation, besides the reducing the force in process, are: process noise reduction and reduction the number of operations necessary to obtain finished pieces.

2. CALCULATION OF THE RELATIVE SPIRAL FEED DURING ORBITAL DEFORMATION

When a cylindrical workpiece is upset during orbital deformation, the equation of the conical surface of the upper die in coordinate system x'y'z' is

$$x'^2+y'^2-z'^2\ ctg^2\theta = 0 \quad (z'\geq 0) \tag{1}$$

where θ is the rocking angle of the upper die (*Fig. 1*).

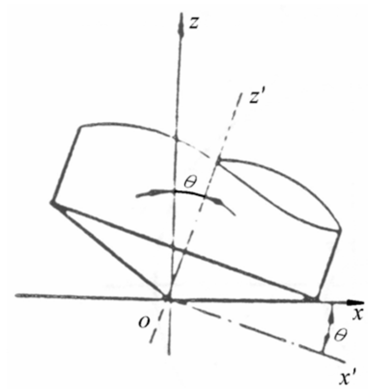


Fig.1 Orbital deformation of a cylindrical workpiece [1],[2]

Rotating anticlockwise the coordinate system by an angle θ, the conical surface becomes

$$y^2 - 2xz\,ctg\theta + z^2(1-ctg^2\theta) = 0 \qquad (2)$$

In addition to rocking of the upper die there is an axial feed of the workpiece. Therefore, the workpiece is upset to form a spiral surface. It is assumed that the speed of revolution of the upper die is n (rpm), the feed velocity of the workpiece will be v (mm/s),. Then, the spiral feed is

$$s = 60\ v/n \quad (mm/r) \qquad (3)$$

Let the horizontal generatrix of the upper die be the x-axis and the vertex be the origin of coordinates. The spiral surface of workpiece can be expressed as

$$z = (1- \Phi_T/2x)\ S_\theta \qquad (4)$$

$$x = r \cos\Phi_T \qquad (5)$$

$$y = r \sin\Phi_T \qquad (6)$$

where Φ_T, r, R are polar angle, polar radius and the radius of the worpiece respectively.
Substituting equations (4),(5) and (6) into equation (2), we have

$$\sin^2\Phi_T r^2 - 2\cos\Phi_T ctg\theta(1- \Phi_T/2x)\ S_\theta r + (1 - ctg^2\theta)(1-\Phi_T/2\theta)^2 S_\theta \qquad (7)$$

This is the polar equation of the contact contour between the upper die and the workpiece during orbital deformation. Let

$$A = \sin^2\Phi_T \qquad (8)$$

$$B = 2\cos\Phi_T ctg\theta\ (1- \Phi_T/2x)\ S_\theta r$$

$$C = (1 - ctg^2\theta)(1-\Phi_T/2x)^2 S_\theta \qquad (9)$$

$$R = (B + B^2 - 4AC)/2A$$

If S_θ, θ and R are given, by means of a computer, we can draw the contact contour during orbital deformation. (Fig. 2)

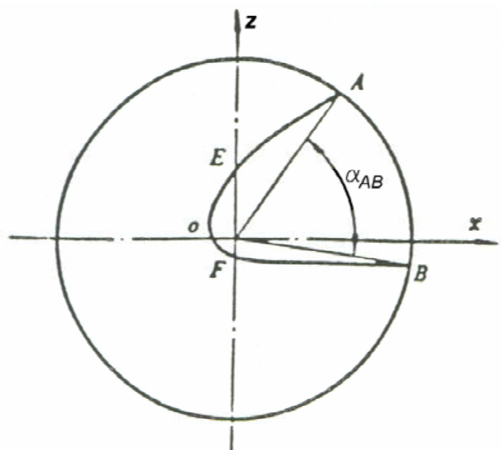


Fig. 2Contact contour during orbital deformation [1],[2]

At point C between A and B, shall have: $T_C = x,\ Y_C = 0,\ Z_C = S_\theta/2$
Substituting these values into equation (2) then we obtain

$$x_C = -\,S_\theta / 2ctg\,2\theta \qquad (10)$$

As a mater of convenience, calculation can be started from the point C, and incremented by $0{,}5^\circ$. Let $T = x \to 0$, up to point A, where the corresponding $r_A = R$. Then let $T = x \to 2x$, calculation is performed up to point B, where $r_B = R$. The angle AB subtended by the arc α_{AB} can be obtained simultaneously

$$\alpha_{AB} = T_A + 2x - T_B \qquad (11)$$

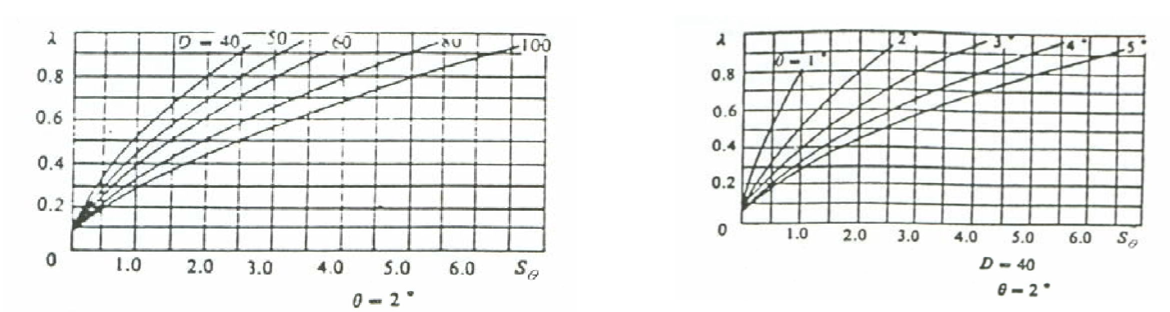
The contact area involved in ACBA can be written as

$$A_R = \frac{1}{2}\cdot\int_{r_A}^{r_B} r^2 dT + \frac{1}{2}\alpha_{AB}\cdot R^2 \qquad (12)$$

The rate of the contact area (λ) is defined as

$$\lambda = A_R / xR^2 \qquad (13)$$

The correlation curves of λ , α_{AB} with respect to S_θ , θ, and R are given in figure 3.



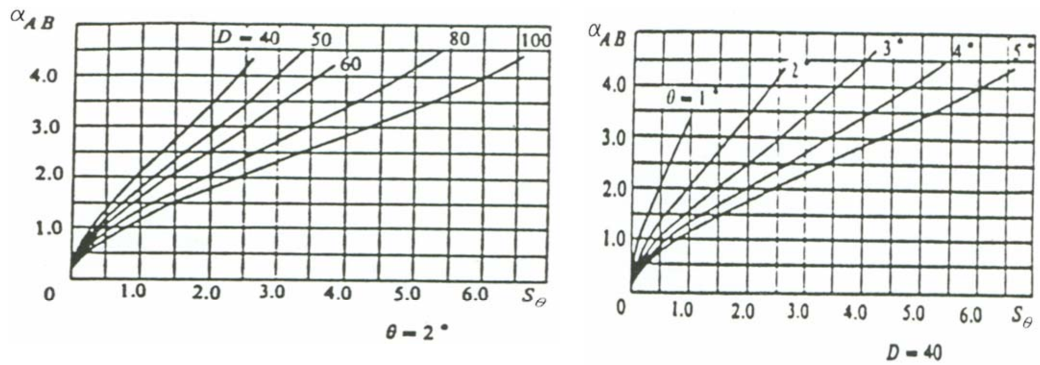


Fig. 3The correlation curves of λ , α_{AB} with respect to S_θ , θ, and R for θ = 2º and D = 40 mm [1],[2]

From figure 2, it is obvious that, in the point E, $x_E = 0$, $T_E = \pi / 2$, $z_E = ¾\ S_\theta$.

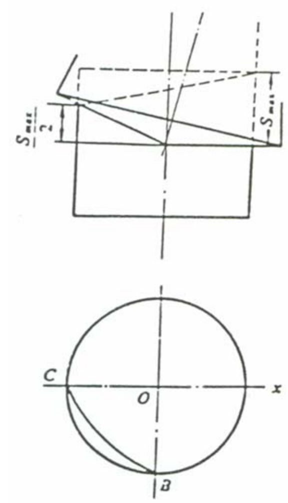


Fig. 4Rate of contact area

It is clear from figure 4, when $x_C = -R$, the rate of contact area has approximated to 100%. We can then define the spiral feed under this condition as the critical s_{max}. When S_θ is more than s_{max}, the workpiece has been deformed entirely instead of deformed partially and the specific characteristic of orbital deformation will be lost. In this condition, from figure 5 we can obtain

$$S_{max} = 2R \text{ tg } 2\theta \quad (14)$$

The relativ spiral feed is defined as

$$S_R = S_\theta / S_{max} = S_\theta / 2R \text{ tg } 2\theta \quad (15)$$

The figure of the contact contour with different values of the relative spiral feed is shown by figure 5.

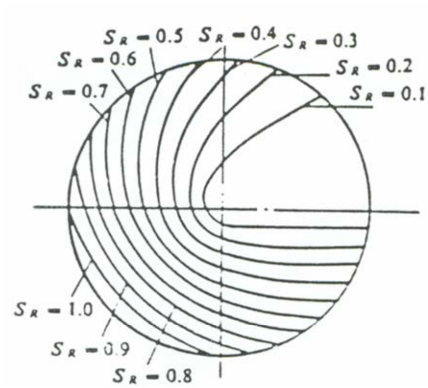


Fig. 5 The contact contour [1],[2]

Substituting equation (15) into equation (10), we obtain

$$x_C = - S_R R \qquad (16)$$

Substituting these values into equation (2) we have :

$$Y_E = 3 \cdot S_R \cdot R\sqrt{1 - tg^2\theta} \approx 3 S_R R \qquad (17)$$

Similarly,

$$Y_E = 3 \cdot S_R \cdot R\sqrt{1 - tg^2\theta} \approx 3 S_R R \qquad (18)$$

$$Y_F = -3 \cdot S_R \cdot R\sqrt{1 - tg^2\theta} \approx -3 S_R R \qquad (19)$$

Figure 6 show the correlation of λand σ_{AB} with respect to the relative spiral feed S_R respectively. For the convenience of application, we can express the relation $S_R=f(\lambda)$ and $S_R=f(\sigma_{AB})$ with the analytical formulas by using the least aquare method. The process of calculating shows that, if we use the unique formulas, the calculated error of λ and σ_{AB} will be too large when $S_R \le 0,1$.

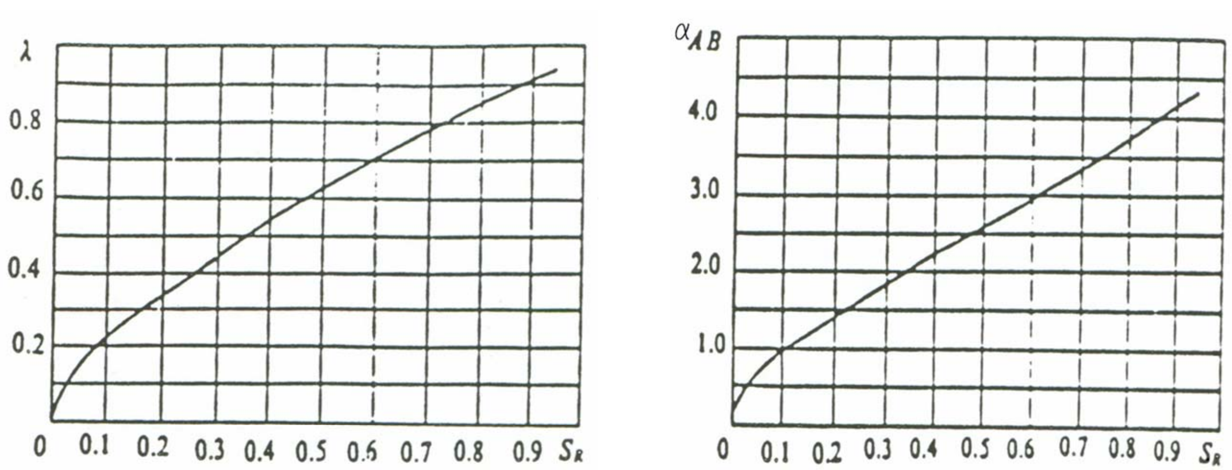


Fig. 6 Correlation of λ and σ_{AB} with respect to the relativ spiral feed S_R [1],[2]

3. CONCLUSION

So it is appropiate to approximate the λ and σ_{AB} with two formulas respectively.

When $S_R \geq 0,1$ $\quad \lambda = 0,98\ S_R^{0,64}$ $\quad$ (R= 0,9997) (19)

When $S_R < 0,1$ $\quad \lambda = 0,76\ S_R^{0,536}$ $\quad$ (R= 0,9996) (20)

When $S_R > 0,1$ $\quad \sigma_{AB} = 3,98\ S_R + 0,624$ $\quad$ (R = 0,9991) (21)

When $S_R \leq 0,1$ $\quad \sigma_{AB} = 3,42\ S_R^{0,546}$ $\quad$ (R = 0,9998) (22)

Where R is coefficient of corelation.

When upsetting a cylindrical workpiece during orbital deformation, it is important to ensure that the length of the arc σ_{AB} to be longer than the height of the workpiece H for the benefit of full deformation. It is assumed that the ratio of the height to the diameter of the workpiece $\eta = H/2R$.

When $S_R > 0,1$ $\quad \sigma_{AB} R = (3,98\ S_R + 0,624)R \geq M$ $\quad S_R \geq 0,503\eta - 0,157$ (23)

For the same reason given above,

When $S_R \leq 0,1$ $\quad S_R \geq 0,375\ \eta^{1,83}$ (24)

Equation (23) and (24) must be satisfied when the technological are satisfied.

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