APENDICES

APPENDIX - A

Proof to show that elastic contact zone is zero for the case of ship-streaming when there is no workhardening

For chip-streaming case , first slipline field (Fig. 4.1(a)) is reduced to slip-line field model as given by Lee and Shaffer [12] (Fig.1.3) . Angle made by α - line at DE is given by $\xi = 1/2 \cos^{-1}(m)$, where m is constant friction factor . Because of strain-hardening , the hydrostatic pressure (p_1) and the yield shear stress (k_1) on the tool face become different from those (p , k) on the slipline AC . Let $p_1 = m_1 p$ and $k_1 = m_1 k$, where m_1 is strain - hardening factor . Assuming power-law distribution of normal stress in the elastic zone , equilibrium of forces normal and along the chip-tool interface and moment about tool-tip yield following equations as follows :

$$(p' \sin\xi + \cos\xi) = m_1 (p' + \sin 2\xi) (1 + x / n + 1) \quad \text{(A.1)}$$

$$pa \cos\xi - ka \sin\xi = k \cos 2\xi b + k . \cos 2\xi . xb / n + 1 \quad \text{(A.2)}$$

$$p' / 2 = m_1 (p' + \sin 2\xi) [y^2 / 2 + y^2 x (1 + x) / n + 1 - x^2 y^2 / n + 2] \quad \text{(A..3)}$$

where $Y = b / a$, $p' = p / k$ and $X = l_e / b$

These equations are solved for unknown parameters y , p' and X to give :

$$y = 1 / (m_1 (1 + X / n + 1) (\cos \xi + \sin \xi)$$

$$p' = 1$$

$$X^2 [m_1 (n+2) - 2 (n+1)] + X [2 m_1 (n+1) (n+2) - 2 (n+1) (n+2)] +$$

$$[m_1 (n+1)^2 (n+2) - (n+1)^2 - (n+1)^2 (n+2)] = 0.0 \qquad \text{(A.4)}$$

The above quadratic equation may be solved to determine the value of X . It may be noted that X becomes equal to zero , when $m_1 = 1$. This indicates that there is no elastic contact for the case of chip-streaming, when there is no strain hardening of work-piece material.

APPENDIX B

Derivation of chip curl radius R_{chip} and moment arm

In fig. 7B.1 the plastic contact length l_p, the width of the chip-breaker W and the height of the chip-breaker h are indicated. The length of the chord EF is denoted as x. Now from triangle EGF, it is obtained

$$x = ((W - l_p)^2 + h^2)^{1/2}$$

The angle made by the chord with tool face at point E is denoted by θ. The value of θ is determined from the geometry of chip-breaker and slipline field as follows:

$$\tan\theta = h / (W - l_p)$$

A normal is drawn on tool face at point E which intersects the line of action of chip-breaking force at point O, which is the center of curvature of chip. Referring to triangle OEF, it is easily seen that the angle OEF and angle OFE are both equal to π / 2 - θ. Using sine law the following relationship is obtained:

$$R_{chip} / \cos\theta = x / \sin 2\theta$$

Hence, $R_{chip} = x / 2 \sin\theta$

But $\sin\theta = h / x$

Hence, $R_{chip} = x^2 / 2h = (W - l_p)^2 / 2h + h / 2$

To determine the values of d (the perpendicular distance from point B in the slipline field to the line of action of the force F_b, a normal CQ is drawn on line FO from point C (tool tip). Similarly another normal is drawn on CQ at point P from point E and a second normal is drawn on PE at point S from O. It is easily seen that the angles CEP and OES are equal to $\pi / 2 - 2\theta$ and 2θ respectively.

Now, $CQ = PQ + PC = OS + PC = R_{chip} \sin 2\theta + l_p \cos 2\theta$

But $d = CQ - CI$

BH and CH are the horizontal and the vertical distance of point B from C which are calculated from the slipline field and are denoted by H_{BC} and V_{BC} respectively. From point B a normal is drawn on CQ at point I and from point H two normals are drawn on BI and CQ at point M and N respectively.

It is easily seen that the angle PCH and the angle MBH are each equal to $2\theta - \gamma_0$.

$CI = CN + NI = CN + MH = HC \cos(2\theta - \gamma_0) + BH \sin(2\theta - \gamma_0)$

Hence, $d = R_{chip} \sin 2\theta + l_p \cos 2\theta - HC \cos(2\theta - \gamma_0) - BH \sin(2\theta - \gamma_0)$

$$= R_{chip} \sin 2\theta + l_p \cos 2\theta - H_{BC} \cos(2\theta - \gamma_0) - V_{BC} \sin(2\theta - \gamma_0)$$

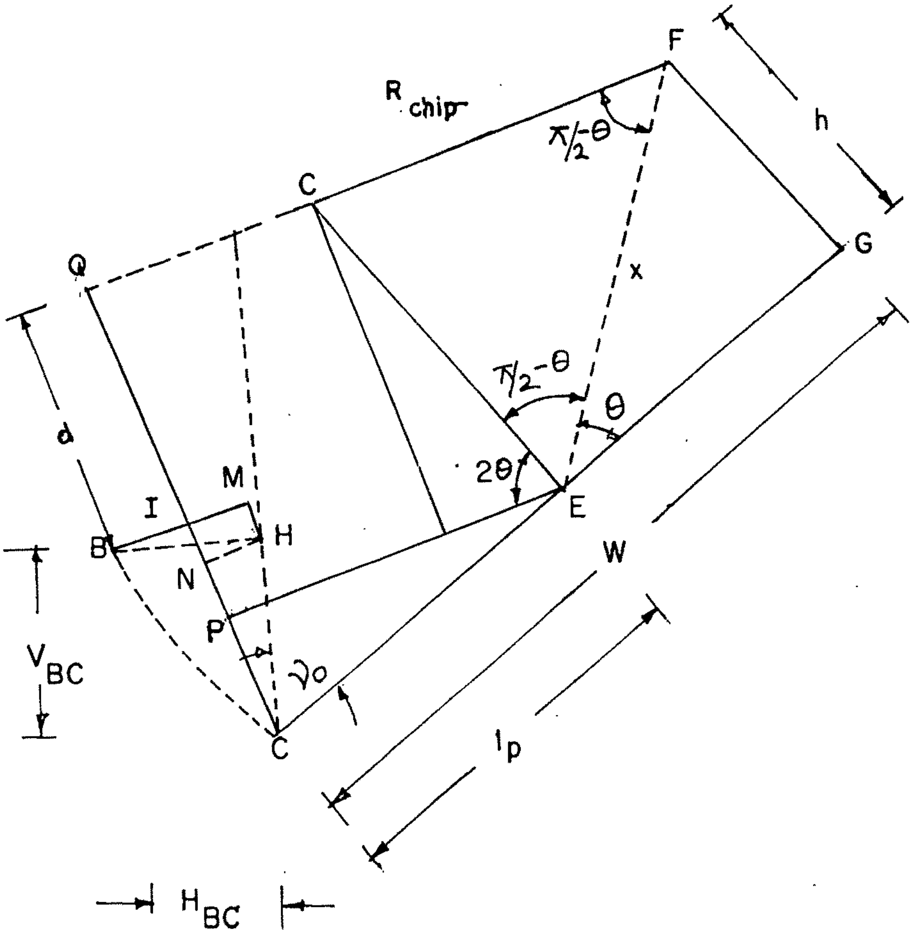

FIG. B.1 CONSTRUCTION FOR DETERMINING CURVATURE OF CHIP AND MOMENT ARM 'd'

APPENDIX-C

Procedure for deriving non-dimensional component of force

$F_S = F_C \cos\beta - F_T \sin\beta$ (C-1)

where, F_S, F_C and F_T are the shear force, tangential cutting force and thrust force respectively and β is the angle of shear.

$\xi = t_1 / t_0$

where t_1 = chip-thickness and t_0 = undeformed chip-thickness = $s.\sin\phi_p$

$\cot\beta = (\xi - \sin\gamma_0) / \cos\gamma_0$ (C-2)

where ξ is the cutting ratio and γ_0 is the rake angle.

For $\gamma_0 = 0$ and $\phi_P = \pi / 2$,

$\cot\beta = \xi$

Now $F_S = k\, t_0\, b / \sin\beta$ (C-3)

where t_0 and b are undeformed chip-thickness and chip-width.

$F_{NC} = F_C / F_S \sin\beta$

$F_{NT} = F_T / F_S \sin\beta$ (C-4)

where F_{NC} and F_{NT} are the non-dimensional cutting force and thrust force respectively.