

**LIST OF NOTATIONS AND ABBREVIATIONS**

$r_p$	radius of punch
$r_{cp}$	corner radius on punch
$r_d$	radius of die opening
$r_{BH}$	corner radius on blank holder
$r_{cd} , r_M$	corner radius on die
$t$	thickness of blank
$r_j$	radius of blank
$D , D_0$	diameter of blank
$d_p , d$	diameter of punch, inner diameter of cup, diameter of the piece that is drawn out
$\sigma_r$	radial stress
$\sigma_\theta$	hoop stress
$d\theta$	angle made by blank element at job axis
$P_h$	blank holder pressure
$\tau$	shear stress acted by the fluid on upper and lower surface of blank element
$2\tau$	total shear stress acted by the fluid on the blank element
$dr$	width of blank element
$r$	radial distance of blank element from job axis
$\sigma_0$	yield stress
$F_1$	shear force
$A_c$	fluid contact area of blank element.

$\sum F_r$	algebraic sum of the forces acting on the blank element in radial direction
$c$	clearance between die and punch = $r_d - r_p$
$(dy)_1$	distance between upper surface of the blank element and blank holder
$(dy)_2$	distance between lower surface of the blank element and die surface
$dy$	distance maintained by blank element from both blank holder and die surface
$\tau_1$	shear stress acted by fluid on upper surface of the blank element
$\tau_2$	shear stress acted by fluid on lower surface of the blank element
$h$	height of the gap
$du$	velocity of the blank element relative to blank holder and die surface
$F_h$	blank holder force
$\sigma_{rd}$	radial stress at die corner
$\sigma_{\theta d}$	hoop stress at die corner
$\sigma_z, \sigma_D$	drawing stress
$F$	drawing force
$\tau_A$	total shear stress acting by the fluid on the blank element
$\frac{du}{dy}$	velocity gradient
$\mu$	dynamic viscosity, coefficient of friction between blank and both the blank holder and die surface, coefficient of friction between belt and pulley

$\theta$	included angle at pulley center made by tensions $T_1$ and $T_2$ (or) contact angle
$T_1, T_2$	tensions
$A^*$	contacting area of stresses $\sigma_z$ and $\sigma_{rd}$
$\sigma_w$	stress caused by bending and unbending
$\sigma_s$	yielding stress of material with hardening property
$\sigma_f$	frictional stress due to blank holder
$R$	instant radius of the blank during forming
$u, v$	punch speed
$F_p^*$	pressure force
$A_p$	surface area of drawing
$k_{sr}$	mean specific resistance
$A_s$	area of contact surface
$\sigma_m$	hardness of material
$A_h$	contact surface area of blank holder
$d_M$	diameter of die opening
$F_p$	plastic forming force
$F_{td}$	friction force of blank holder
$F_{tk}$	splitting friction force of sheet metal over the radius of die opening
$F_s$	bending force over corner radius on die
$F_{mo}$	total force in conventional deep drawing process
$F_{ho}$	total hydroforming force

$F_{pf}$	fluid pressure force
$P_f, P$	fluid pressure
$k_0$	yield stress in pure shear
$m, \beta$	drawing ratio.
$d\varepsilon_\theta$	hoop strain
$d\varepsilon_r$	radial strain
$q$	discharge
$g$	gap
$r_0$	gap external radius
$r_i$	gap internal radius
$F_{P_1}$	total punch force
$F_D$	sheet drawing force
$P_s$	pressure of liquid in the die cavity
$P_a$	pressure of the fluid pushing on the blank Periphery
$P_b$	pressure of liquid along the blank rim or liquid pressure loaded onto the lower surface of the blank
CFD	computational fluid dynamics
FEA	finite element analysis