

Nomenclature / Notations

α	:	semi cone angle of flow formed cone
2α	:	included angle of the flow formed cone
$2\alpha_m$:	minimum included angle of the cone that can be flow formed from flat metal blank
β	:	angle of inclination of roller land to the cone surface
$(\delta l)_n$:	percentage deviation of cone wall thickness from the set sine thickness
ε	:	principal true strain
$\dot{\varepsilon}$:	true strain rate
$\bar{\varepsilon}$:	effective strain
ϕ	:	angle of inclination of the roller exit line to the cone surface
γ	:	shear strain
$\bar{\sigma}$:	effective stress
$\bar{\sigma}_m$:	mean effective (flow) stress
σ_0	:	the yield or flow stress measured in the uniaxial tension test
$\sigma_1, \sigma_2, \sigma_3$:	Principal stresses ($\sigma_1 > \sigma_2 > \sigma_3$)
σ_r	:	radial stress at necked region
τ	:	original sheet metal blank thickness
τ_{max}	:	maximum shear stress
(AB), (AC), (BC), (ABC)	:	interaction effect of the factors of AxB, AxC, BxC, AxBxC respectively
A, B, C	:	factor code for T, N, f respectively in flow formability equation
A, B, C	:	factor code for R, N, f respectively in accuracy and surface finish equation
a_0, a_1, a_2	:	low center and high levels of factor A
Al	:	aluminium
ANOVA	:	analysis of variance
A_r, A_a, A_t	:	three projection of contact area between the roller and cone

in three coordinate directions r, z, θ

b_0	:	constant
$b_0, b_1, b_2, b_3, \dots$:	estimates of $B_0, B_1, B_2, B_3, \dots$ etc. in response equations
b_0, b_1, b_2	:	low center and high levels of factor B
$B_0, B_1, B_2, B_3, \dots$:	true coefficients in response equations
b_1, b_2, b_3	:	estimates of the coefficients of the factors in the polynomial equation
c_0, c_1, c_2	:	low center and high levels of factor C
CLA	:	centre line average
Cu	:	copper
d. f	:	degrees of freedom
DDS	:	deep drawn grade steel
dl	:	distance of contact between the roller and the cone during infinitesimal time dt.
dv	:	infinitesimal volume of cone being flow formed
e	:	experimental error
f	:	feed rate of forming roller
F	:	Fisher ratio
F_t	:	tangential force component acting on forming roller
m	:	order of interaction
M. S	:	mean square
N	:	mandrel rotational speed
n	:	number of factors examined
p	:	number of linear term in the interaction
P	:	probability
R	:	percentage reduction in cone wall thickness
r	:	number of replicates
RA	:	reduction in area at fracture in tensile testing
R_a	:	CLA value of surface roughness
R_f	:	measure of flow formability = maximum percentage

reduction in wall thickness in flow forming

S	:	std. deviation/error
$S.S$:	sum of square
S^2	:	experimental test error variance
t	:	wall thickness of the conical part
T	:	original sheetmetal blank thickness
t_f	:	final wall thickness of flow formed part just before fracture
t_{max}	:	measured maximum wall thickness
V	:	deformation velocity
$V(b)$:	variance of estimated coefficients
X_1, X_2, X_3	:	independent variables derived from the controlling factors
y	:	observed response value
Y	:	true response
\hat{y}	:	predicted/estimated value of y
y_{aa}	:	dimensional accuracy of aluminium cones
y_{as}	:	surface finish of aluminium cones
y_{ca}	:	dimensional accuracy of copper cones
y_{cs}	:	surface finish of copper cones