Single Point Cutting Tool Geometry

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Outline

• Tool Geometry, Tool Angles
• Systems for Tool nomenclature
  - ISO System - ORS/NRS
  - American Standards System - ASA
• Tool Angle Conversion: ISO ↔ ASA
  - Mathematical Basis
Basic Tool Shape

Wedge angle : $2\beta$

Work

P

Tool

$2\beta$
Cutting Efficiency

\[ P = 2R \sin \beta \]

Cutting Efficiency = \( \frac{R}{P} \)

\[ \eta \propto \frac{1}{\sin \beta} \]
Orthogonal Cutting

![Diagram of orthogonal cutting tool and workpiece with labels for rake angle, flank angle, cutting edge, chip, and workpiece dimensions. velocity V is indicated.]
Orthogonal Cutting

Characteristics

• Cutting edge **Perpendicular** to cutting Velocity Vector
• Plain Strain (2D) phenomenon
• **No Spread** of material across
Oblique Cutting

Tool

Chip

λ

Work piece

V
Oblique Cutting

Characteristics

• Cutting edge at an angle ($\lambda$) to normal to velocity vector in the cutting plane

• Inclination angle $\lambda$
  - modifies Tool angles
  - governs Direction of chip flow

Stabler’s Law for Chip flow

$$n_c = k \cdot \lambda$$

$nc = \text{chip flow angle}$

$K = 0.8 - 1.0$
Free and Restricted Cutting

[Diagram showing the process of cutting with labels for Workpiece, Tool, and Feed Motion]
Chip Flow

Free

Restricted
Single Point Tool Geometry

- rake surface
- principal cutting edge
- principal flank (clearance) surface
- auxiliary cutting edge
- tool nose
- auxiliary flank (clearance) surface
Tool Nomenclature Systems

Tool in Hand

- ISO System: ORS/ NRS
  - Orthogonal/ Normal Reference System
- American Standards Association (ASA) system

Tool in Machine

- Tool /Insert setting in fixture
Tool Angle Reference Systems
ORS and ASA

\[ \gamma_x \]

\[ \gamma_o \]

\[ \gamma_y \]

\[ \lambda \]
Tool Reference Planes

- $\pi_c$: Cutting Plane
- $\pi_o$: Orthogonal Plane
- $\pi_B$: Basic Plane

Feed

$\pi_c \rightarrow \pi_o \rightarrow \pi_B$

$\mathbf{v}$: Axis
Orthogonal (ORS) Reference Planes

Trace of $\pi_o$

Trace of $\pi_c$

$\pi_B$

$\pi_c$ $\pi_o$

$\pi_B$
Reference Planes - ORS

View in $\pi_c$

View in $\pi_o$

$\pi_c$, $\pi_o$, $\pi_B$
Reference Planes – ASA system
ASA Reference Planes

\[ \pi_x \]

\[ \pi_y \]
Tool Angles – ASA System

View in $\pi_x$ Plane

View in $\pi_y$ Plane
Tool Angles

\[ \phi = \text{Plan Approach angle} \]
\[ \phi_s = \text{Side cutting Edge angle} \]
\[ \phi_e = \text{End cutting Edge angle} \]
\[ \phi = 90 - \phi_s \]
Tool Designation

ASA System

\( \gamma_y, \gamma_x, \alpha_y, \alpha_x, \phi_e, \phi_s, r \)

- \( \gamma_y \): Back rake angle
- \( \gamma_x \): Side rake angle
- \( \alpha_y \): Front clearance angle
- \( \alpha_x \): Side clearance angle
- \( \phi_e \): End cutting Edge angle
- \( \phi_s \): Side cutting Edge angle
- \( r \): Nose radius (mm)
Tool Angle Conversion

ORS $\rightarrow$ ASA

$(\gamma_o, \lambda) \rightarrow (\gamma_x, \gamma_y)$

\[
\begin{bmatrix}
tan\gamma_x \\
tan\gamma_y
\end{bmatrix} =
\begin{bmatrix}
sin\phi & -cos\phi \\
cos\phi & sin\phi
\end{bmatrix}
\begin{bmatrix}
tan\gamma_o \\
tan\lambda
\end{bmatrix}
\]

$\phi = \text{Plan Approach angle}$
Tool Angle Conversion

ASA $\rightarrow$ ORS

$(\gamma_x, \gamma_y) \rightarrow (\gamma_o, \lambda)$

$$\begin{bmatrix} tan\gamma_o \\ tan\lambda \end{bmatrix} = \begin{bmatrix} sin\phi & cos\phi \\ -cos\phi & sin\phi \end{bmatrix} \begin{bmatrix} tan\gamma_x \\ tan\gamma_y \end{bmatrix}$$

$\phi = \text{Plan Approach angle}$
Does Orthogonal Plane $\pi_o$ represent True rake angle?
Orthogonal and Normal Reference Planes
Tool Angle Conversion

ORS $\rightarrow$ NRS

$\gamma_o \rightarrow \gamma_n$

$tan\gamma_n = tan\gamma_o \cdot Cos \lambda$
Tool in Machine System

Static angles on Tool/Insert change due to

• Setting in tool Holders/ Fixtures
• Tool/ Work relative motion.
Inserts in Tool Holder
## Inserts and Tool Angles

<table>
<thead>
<tr>
<th>Insert</th>
<th>Tool cutting edge angle</th>
<th>Insert</th>
<th>Tool cutting edge angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td><img src="image1" alt="Diagram" /> 80°</td>
<td>W</td>
<td><img src="image2" alt="Diagram" /> 80°</td>
</tr>
<tr>
<td></td>
<td><img src="image3" alt="Diagram" /> 95°</td>
<td></td>
<td><img src="image4" alt="Diagram" /> 95°</td>
</tr>
<tr>
<td>V</td>
<td><img src="image5" alt="Diagram" /> 35°</td>
<td>T</td>
<td><img src="image6" alt="Diagram" /> ≤ 25°</td>
</tr>
<tr>
<td></td>
<td><img src="image7" alt="Diagram" /> 93°</td>
<td></td>
<td><img src="image8" alt="Diagram" /> ≤ 22°</td>
</tr>
<tr>
<td>T</td>
<td><img src="image9" alt="Diagram" /> 91°</td>
<td>S</td>
<td><img src="image10" alt="Diagram" /> 75°</td>
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<tr>
<td></td>
<td><img src="image11" alt="Diagram" /></td>
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<td><img src="image12" alt="Diagram" /></td>
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Tool Setup on Machine