Cutting Tool Design – General Consideration

The design of a cutting tool comprises of the following:-

1) Determination of size and shape of all the element of the tool comprising cutting element and mounting element by analytical or graphical method.
2) Finding the ~~optium~~ optimum tool geometry and shape of the tool.
3) Selecting a suitable tool material. Heat treatment if any.
4) Finding the tolerances on the dimensions of the cutting and mounting elements of the tool, guided by the accuracy required
5) Based on the cutting forces finding the strength and rigidity of the cutting and mounting elements of the tool.
6) Preparation of the drawing of the cutting tool giving all the necessary specification and tolerances.

Special attention is to be paid for the design of the mounting element like shank, the purpose of which is to

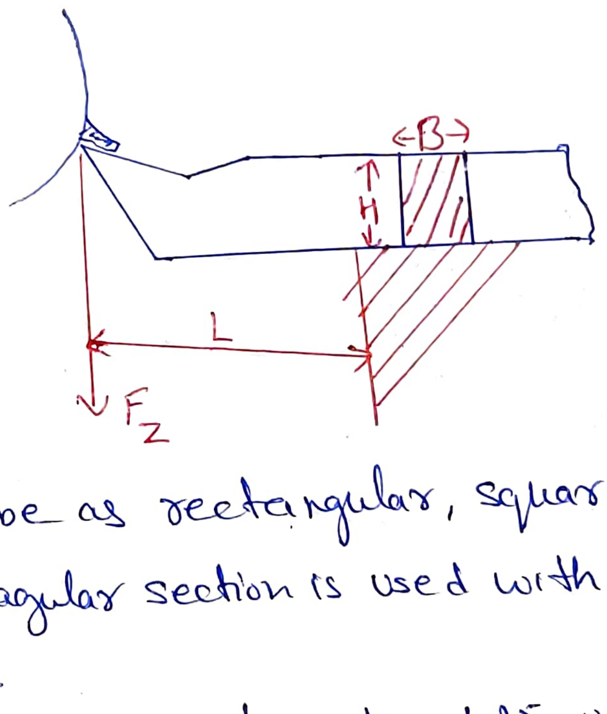
1) Ensure the required accuracy of location of the cutting tool in the machine spindle.

2) Provide for interchangeability of the tool in the spindle.

3) Ensure mounting of the tool with ease and little loss of time.

4) Effectively transmit the forces and torque on the tool without much loss and damage to the tool.

Design of Single-Point Tool The shank of a single-point tool is designed from consideration of strength and rigidity. The tool is assumed to be loaded as a cantilever by cutting forces acting as its tip.



Tool shank may be as rectangular, squar or round. Normally rectangular section is used with H/B ratio is 1.25 or 1.6.

For roughing operation H/B ratio 1.25 use

semi-finishing or finishing operation H/B ratio 1.6 use

L = over hang length of the tool after clamp.

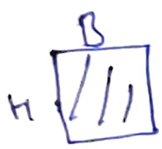
F_z = Cutting force component

σ_b = Permissible bending stress of the shank material.

M_b = Bending moment

I = Moment of inertia.

Z = Section modulus of the tool shank, mm^3

Section		Z	I
	rectangular	$Z = \frac{BH^2}{6}\ mm^3$	$I = \frac{BH^3}{12}\ kgf/mm^2$
	square	$Z = \frac{B^3}{6}\ mm^3$	$I = \frac{B^4}{12}\ kgf/mm^2$
	round	$Z = \frac{\pi d^3}{32}\ mm^3$	$I = 0.05\, d^4\ kgf/mm^2$

$$F_z L = \sigma_b Z$$

$$F_z L = \frac{BH^2}{6} \cdot \sigma_b$$

$$BH^2 = \frac{6 F_z L}{\sigma_b}$$

or

$$\boxed{\sigma_b \geq \frac{6 F_z L}{BH^2}}$$

Checking for rigidity

$$\boxed{\delta \geq \frac{F_z L^3}{3EI}}$$

δ = Permissible deflection of the tool. (considering)

Considering tool as cantilever,

$\delta = 0.1$ mm for roughing operation

~~$\delta = 0.05$ mm~~

$\delta = 0.05$ mm for finishing operation.

E = young's modulus of the tool shank material.

8) In a rough turning operation with a straight shank brazed tool of rectangular section mounted with an overhand of 60 mm, the main cutting force was found to be 232 kgf. The tool body is made of a carbon steel having permissible bending strength 20 kgf/mm² and modulus of elasticity $E = 2 \times 10^4$ kgf/mm². If permissible deflection of the tool tip is $\delta = 0.1$ mm, determine the tool dimension.

Sol) Given Data

$H/B = 1.6$ For rectangular section.

$\sigma_b = 20$ kgf/mm²

$E = 2 \times 10^4$ kgf/mm²

$\delta = 0.1$ mm

$F_z = 232$ kgf

L = 60 mm

B = ?

H = ?

$$\sigma_b = \frac{6 F_z L}{B H^2}$$

Put $H = 1.6B$

$$B = \sqrt[3]{\frac{6 F_z L}{2.56 \sigma_b}} \text{ mm}$$

$B = 16.31$ mm ≈ 16 mm

$H = 25$ mm

The max. load that the selected section can bear from consideration of strength is again found.

$$F_z = \frac{BH^2 \sigma_b}{6l}$$

$$F_z = 555 \text{ kgf.}$$

The max. load that the seleted section can bear from consideration of stiffness is found.

$$F_z = \frac{EBH^3 \delta}{4l^3}$$

$$F_z = 578.7 \text{ kgf}$$

Both F_z values is higher the actual cutting forces value, so design is safe.