■The necessary characteristics of a punching tool

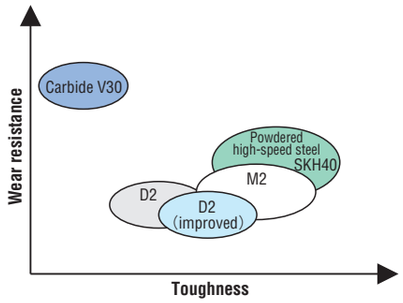
include good wear resistance, high compression resistance, high impact resistance and toughness, and high fatigue strength.
Punching tool materials must be selected to suit the punching conditions, such as the production quantity, workpieces, and lubrication.

■Characteristics of tool steel

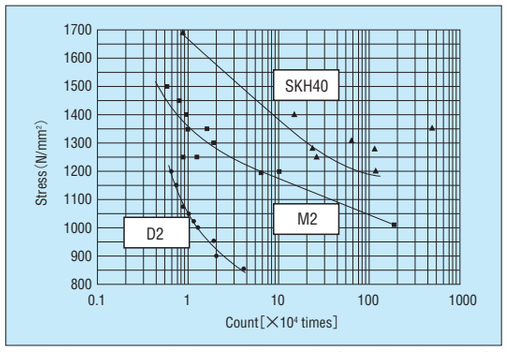
Alloy tool steel	D2	12% Cr D2 has excellent wear resistance and good hardenability, which leads to reduced deformation. This is the type of tool steel most often used.
	D2 (improved)	High-temperature tempering results in hardness of HRC60～63, increasing the toughness of the steel.
High-speed tool steel	M2	M2 is the type of high-speed steel most often used. It features excellent wearresistance and toughness.
Powdered high-speed tool steel	SKH40	Powder metallurgical techniques yield powdered steel with an even structure, and because it contains large quantities of high alloying components (such as W, V, and Co) which were unavailable before, this steel has excellent toughness, wear resistance, and fatigue strength.
Carbide	V30	Compared with ordinary steel, this material has higher hardness and superior wear resistance, compression resistance, rigidity, and heat resistance. However toughness is poor, and if this material is selected incorrectly, its full performance cannot be achieved.

■Effects of alloying elements

Element	Effect
C	Forms carbides in combination with Cr, W, Mo, V, and other elements, providing wear resistance.Hardness increases with higher content.
Cr	Improves wear resistance, corrosion resistance and hardenability.
Mo, W	Forms hard complex carbides in combination with Fe, Cr, and C, improving wear resistance, hardenability, and hardness at high temperatures.
V	Improves wear resistance and toughness.
Co	Improves high-temperature hardness and tempering hardness.
Mn	Improves hardenability and toughness.



■Characteristics of punching tools



■Fatigue strength of punching tools (rotating bending)

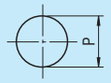
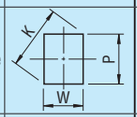
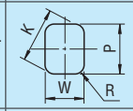
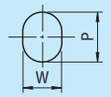
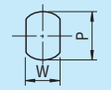
Fatigue strength varies largely depending on the conditions of surface treatment, heat treatment, and other factors. Use this diagram as a reference guide.

■Material characteristics of punching tools

Item \ M		Alloy tool steel		High-speed steel	Powdered high-speed steel	Carbide
		D2	D2 (improved)	M2	SKH40	V30
Chemical composition (%)	C	1.5	8% Cr die steel	0.85	1.3	Co : 12% Other : WC
	Cr	12		4.15	4	
	Mo	—		6.5	6	
	W	1		5.3	5	
	V	0.35		2.05	3	
	Co	—		—	8	
	Mn	0.45		0.35	—	
Hardening temperature [℃]		1000～1050	1020～1040	1180～1220	1120～1190	—
Tempering temperature [℃]		150～200	520～550	550～570	560～580	—
Hardness	HRC	60～63	60～63	61～64	64～67	1200—1350 HV
Traverse rupture force	N/mm²	3500	4500	4800	4500	2500
Young´s modulus	N/mm²	210000	217000	219000	228600	540000
Density	g/cm³	7.72	7.87	8.11	8.07	14.4
Thermal expansion coefficient	×10⁻⁶/℃	12.0	12.2	10.1	10.1	5.4
Thermal conductivity	W/m·k	29.3	23.7	20.6	23.8	72

Note: • The data presented here represents typical values; they are not guaranteed values.
• Powdered high-speed steel SKH40 has been standardized by JIS G 4403 : 2000.
(Examples include Hitachi Metal HAP40, Kobe Steel KHA30, Daido Steel DEX40, and Nachi-Fujikoshi FAX38.)

Shapes of punches and dies

Shape		Profile length of tip ℓ	Diagonal (circumscribing circle) K	Cross section area S
Round		πP	P	$\pi P^2/4$
Square		$2(P+W)$	$\sqrt{P^2+W^2}$	PW
Corner R		$2\pi R+P+W-4R$	$2R+\sqrt{(P-2R)^2+(W-2R)^2}$	$PW-(4R^2-\pi R^2)$
Oblong		$\pi W+2(P-W)$	P	$\frac{\pi}{4}W^2+W(P-W)$
Key flat		$2\sqrt{P^2-W^2}+(\pi P \sin^{-1}W/P)/90$	P	$\pi P^2/4-(\pi P^2-\cos^{-1}W/P)/360+W/2\sqrt{P^2-W^2}$

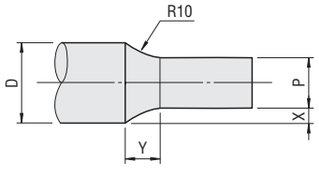
■Finding the length of R (Y)

①Length of punch R (Y)

Find Y from X=(D—P)/2.

$Y=\sqrt{X(20-X)}$ ……For R10

$Y=\sqrt{X(2R-X)}$ ……For other than R10



Example 1: Finding Y for SPAS10—60—P6.80

X=(D—P)/2=(10—6.8)/2

=1.6

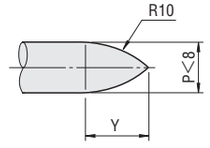
$Y=\sqrt{1.6(20-1.6)}\fallingdotseq 5.426$

②Length of pilot punch R (Y)

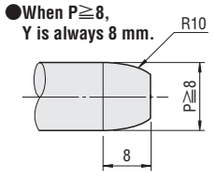
$Y=\sqrt{P(10-P/4)}$ ……For R10

$Y=\sqrt{P(R-P/4)}$ ……For other than R10

●When P＜8



●When P≧8, Y is always 8 mm.



Example 2: Finding Y for SPT5—20—P4.5

$Y=\sqrt{P(10-P/4)}$

$=\sqrt{4.5(10-4.5/4)}\fallingdotseq 6.32$