

Surface Hardening of Tool and Die Steels

Flame, induction, electron beam and laser hardening raise the hardness of a working surface without adding an alloying element, so the carbon the grade already has fixes what the surface can reach. The tables below give the case depth, the speed and the part limits of each process, and the hardness the tooling grades reach after flame hardening in air, oil and water.

Reference only. This is a reference summary of published practice and it is not a specification of ours. The values are reproduced from the source tables, and what a particular tool reaches depends on the grade, the section, the equipment and the cycle that follows. Final selection is confirmed on the job.

Four processes that harden a surface without changing its chemistry

Process	Feed to the tool	Depth of hardening	Applicable material	Speed of heating	Processing	Part size	Where it fits
Flame	Oxyfuel torch with a special head, plus a quench system	1.2 to 6.2 mm (0.050 to 0.250 in.)	Ferrous alloys, carbon steels, alloy steels, cast irons	A few seconds to a few minutes per part	One part at a time	No size limit	Low equipment cost, best for large work, significant operator skill required, hot work with eye protection
Induction	Power supply, water cooled copper inductor, quench system	0.4 to 1.5 mm (0.015 to 0.060 in.); 0.1 mm (0.004 in.) for impulse	The same steels as flame hardening	1 to 10 s	One part at a time	The part must fit inside the coil	High equipment cost, best for small work, very precise control, little skill needed after setup

Flame hardening and induction hardening compared. Depth, speed, part size and cost are reproduced from the comparison table in the source. Flame hardening reaches deeper, induction is faster and more precise, and the two are used on the same steels.

Electron beam and laser: self quenching, no quenchant

Which tool steels these processes are cleared for

How much carbon the surface needs

Typical hardness after flame hardening, by grade and quenchant

Surface Hardening of Tool and Die Steels

Material	Air(a)	Oil(b)	Water(b)
Plain carbon steels			
1025-1035	...	...	33-50
1040-1050	...	52-58	55-60
1055-1075	50-60	58-62	60-63
1080-1095	55-62	58-62	62-65
1125-1137	...	...	45-55
1138-1144	45-55	52-57(c)	55-62
1146-1151	50-55	55-60	58-64
Carburized grades of plain carbon steels(d)			
1010-1020	50-60	58-62	62-65
1108-1120	50-60	60-63	62-65
Alloy steels			
1340-1345	45-55	52-57(c)	55-62
3140-3145	50-60	55-60	60-64
3350	55-60	58-62	63-65
4063	55-60	61-63	63-65
4130-4135	...	50-55	55-60
4140-4145	52-56	52-56	55-60
4147-4150	58-62	58-62	62-65
4337-4340	53-57	53-57	60-63
4347	56-60	56-60	62-65
4640	52-56	52-56	60-63
52100	55-60	55-60	62-64
6150	...	52-60	55-60
8630-8640	48-53	52-57	58-62
8642-8660	55-63	55-63	62-64
Carburized grades of alloy steels(d)			
3310	55-60	58-62	63-65
4615-4620	58-62	62-65	64-66
8615-8620	...	58-62	62-65
Martensitic stainless steels			
410, 416	41-44	41-44	...
414, 431	42-47	42-47	...
420	49-56	49-56	...
440 (typical)	55-59	55-59	...
Cast irons (ASTM classes)			
Class 30	...	43-48	43-48
Class 40	...	48-52	48-52
Class 45010	...	35-43	35-45
50007, 53004, 60003	...	52-56	55-60
Class 80002	52-56	56-59	56-61
Class 60-45-15	...	...	35-45
Class 80-60-03	...	52-56	55-60

Response of steels and cast irons to flame hardening, by quenchant, reproduced from the source table. (a) To obtain the hardness shown, areas not directly heated must be kept relatively cool during heating. (b) Thin sections are susceptible to cracking when quenched with oil or water. (c) Hardness is slightly lower for material heated by spinning or combined progressive-spinning methods than for progressive or stationary heating. (d) Hardness values of carburized cases containing 0.90 to 1.10% C. Induction hardening uses the same steels and the same response.

Where each process belongs on a tool steel order

Aobo Steel, tool steel supplier

Aobo Steel supplies tool steel to distributors and mold, tool and die shops, including D2, D3, DC53, A2, O1, H13, H11, H10, H21, S7, M2, M42, L6, P20 and 420 and 440C stainless. Forged or hot rolled, annealed or pre-hardened, cut to your sizes, with test certificates.
Source, ASM Handbook, Volume 20, Materials Selection and Design, ASM International, 1997.

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