

Tool Steels in Woodturning

Which is Right for You?

High Carbon vs High Speed Steel

Carbon Steel (0.5-2.0%)

- Excellent edge, but not durable
- Easy to draw temper (bluing)
 - Turning is very abrasive

High Carbon vs High Speed Steel

- High Speed Steel
 - Developed 100 years ago for metal
- Properties
 - High hardness, even at high temperatures
 - Abrasion (wear) resistance
 - Toughness for interrupted cuts

Turners First Using HSS

- Peter Child UK
 - Superflute
- Soren Berger NZ
 - Bar Gouges
- Jerry Glaser USA
 - New Alloys and Grinds

Comparison of Various Tool Steels

TYPE	TYPICAL CHEMICAL COMPOSITION (%)						HARDNESS	
	Carbon C	Chromium Cr	Tungsten W	Molybdenum Mo	Vanadium V	Cobalt Co	Maximum Annealed Hb	Typical Tempered HrC
M-2	0.83	4.15	6.15	5.10	1.95	~	255	64
M-3	1.05	4.15	6.15	5.75	2.50	~	255	66
M-4	1.30	4.25	5.85	4.75	4.10	~	255	65
PM M-4	1.40	4.00	5.65	5.20	4.00	~	255	65
PM-30	1.25	4.20	6.40	5.00	3.10	8.50	260	65
PM-60	2.30	4.20	6.50	7.00	6.50	10.50	340	67
PM A-11	2.45	5.25	.5 max	1.30	9.75	.5 max	255	63

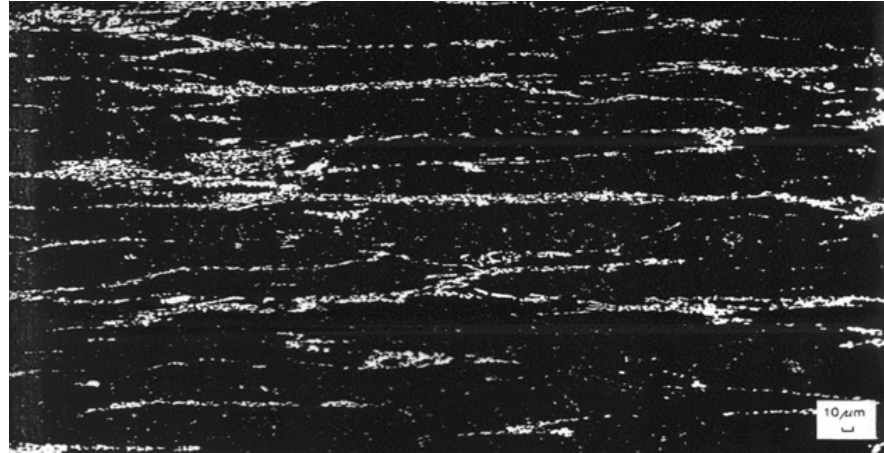
What Is Particle Metal?

- Not Cast
- Sintered or atomized metals added to mold
- Heated in Mold
 - Bars or flat stock
- More Uniform Structure
 - Smaller carbides
 - Tougher

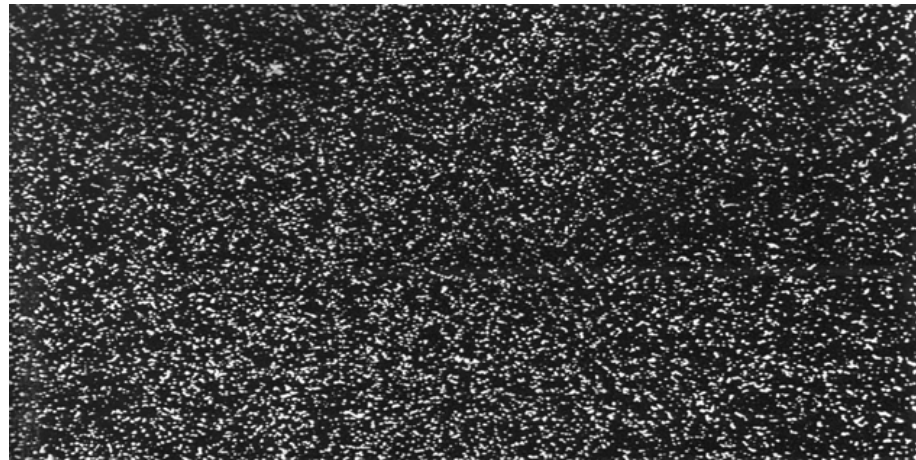
Microstructure of HSS

Conventional

(carbides white)



Powder Metal



Heat Treating HSS

Where the action is

- Preheat to 1500 F
- Heat to 2200 F for 2-5 min
- Quench to 1000 F, then air cool
- Temper at 1000 F for 2h+
 - Cryo Treatment <300 F here
- Repeat Temper

Qualities of HSS for the Turner

- High Hardness
 - Rc 62-68
- High Wear Resistance
 - Edge Retention
 - Carbide microstructure
- Retains Temper and Hardness at High Temperatures
- Impact Toughness
 - Interrupted Cutting

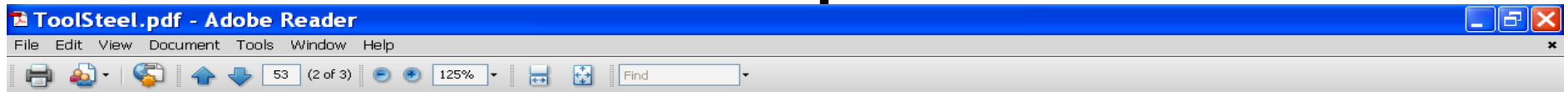
HIGH SPEED STEEL PROPERTIES

GRADE	WEAR RESISTANCE	TOUGHNESS	RED HARDNESS	EASE OF GRINDING
M2	██████████	██████████	██████████	██████████
M4	████████████████	██████	██████████	██
PM M4	████████████████	████████████████	██████████	██████████
PM 30	██████████	██████████	████████████████	██████████
PM 60	████████████████	██████	████████████████	██
PM A11	████████████████	██████████	N/A	██

“Sharpness” Of HSS

- M2 > M4 > V10 = 2030 > V15 > 2060
- More complex alloys are more brittle, so lower relief angle.
- Type 1 vs Type 2 Cuts
- Grinding Carbon and HSS
 - Spark Test
 - Grinding Wheels and Speed
 - 8 in Optimum
 - Friable Wheel (3X, AlOx, Ruby)
 - Low (1750) or High (3450) Speeds
 - Advantages of HSS
 - Can't draw the temper
 - Beware water quenching

Comparison of Commercial Tool Steel Compositions



Sufficient impact toughness to handle interrupted cutting applications, to avoid chipping during cutting, and to avoid breakage in

5 minutes.
 • Quench in salt bath or oil to 1,000–1,100°F, then air-cool to hand warm (150°F). Temper immediately.

tools that confuse many turners. First is the use of powdered or particle metals (PM). This is a process in steel making that yields

WOODTURNING TOOL-STEEL ANALYSIS		COUNTRY OF ORIGIN	CARBON BY %	MANGANESE BY %	PHOSPHORUS BY %	SULFUR BY %	COBALT BY %	SILICON BY %	CHROMIUM BY %	NICKEL BY %	MOLYBDENUM BY %	COPPER BY %	VANADIUM BY %	TUNGSTEN BY %	IRON	HARDNESS (HRC)	PROBABLE STEEL*
BRAND																	
Packard (Hamlet)	UK	2.30	0.00	0.00	0.00	10.70	0.77	4.00	0.00	7.10	0.00	6.60	6.50	B ¹	68.0	2060 ⁵	
Sorby	UK	0.91	0.27	0.02	0.00	0.00	0.24	4.03	0.00	4.79	0.00	1.75	5.96	B ¹	65.0	M2 ⁶	
Apprentice (Craft Supplies)	CHINA	0.87	0.40	0.03	0.02	0.00	0.30	3.95	0.00	4.55	0.00	1.83	5.99	B ¹	64.0	M2 ⁶	
Benjamin's Best (eBay ²)	CHINA	0.85	0.35	0.02	0.02	0.02	1.18	4.50	0.07	0.29	0.11	0.12	2.41	B ¹	65.0	UN ⁷	
Benjamin's Best (Penn State)	CHINA	0.86	0.62	0.03	0.02	0.05	0.36	3.91	0.11	4.73	0.15	1.93	6.34	B ¹	58.0	M2 ⁶	
Bodger (Highland Hardware)	CHINA	1.05	0.39	0.03	0.01	0.02	0.50	4.11	0.05	0.45	0.12	0.40	2.46	B ¹	57.0	UN ⁷	
Grizzly	CHINA	0.85	0.37	0.02	0.01	0.23	0.61	4.13	0.15	2.18	0.15	0.97	4.37	B ¹	62.0	HSS ⁸	
Harbor Freight	CHINA	0.74	0.17	0.02	0.01	0.00	0.27	4.11	0.00	0.00	0.00	1.04	17.61	B ¹	62.2	T1 ⁶	
Pinnacle (Woodcraft)	CHINA	0.87	0.70	0.03	0.02	0.00	0.36	4.21	0.00	4.81	0.00	2.03	6.23	B ¹	61.7	M2 ⁶	
Sears Craftsman	CHINA	0.82	0.26	0.0	0.00	0.03	0.56	4.10	0.11	3.97	0.09	0.97	0.05	B ¹	61.0	M50 ⁹	
Shopsmith ³	CHINA	0.94	0.11	0.02	0.01	0.09	0.22	4.02	0.11	4.50	0.14	1.68	5.84	B ¹	64.0	M2 ⁶	

1. Balance of tool composition is iron.
 2. Purchased new via eBay auction.
 3. Part of a 4-piece bowl-turning set (not the standard 5-piece Shopsmith turning set).
 4. Interpretations contributed by Stork laboratory technicians, Dr. Jeryl Wright, and Jerry Glaser.
 5. 2060 is a particle or powdered metal (PM) HSS with extremely high wear-resistance properties.
 6. M2 and T1 are long-established HSS compositions with good track records.
 7. Unknown steel. Failed high-speed steel (HSS) test as defined by the American Society for Testing Materials (ASTM). HSS must contain specified amounts of carbon, chromium, vanadium, tungsten, and molybdenum.
 8. Meets the minimum amounts to be called an intermediate HSS.
 9. M50 is a HSS, primarily used for bearings, but with low-wear resistance.

Results of Metal Composition Tests on Turning Tools

- Most found to be M2
- Several brands not HSS and/or too soft (<Rc 62)
(Benjamin's Best, Bodger, Harbor Freight)
- Grizzley was barely (pun intended) HSS
(low Mo, high Si)
- Sears Craftsman was inappropriate HSS (M50)
- Courtesy AAW Journal Summer 2008

Sharpness vs Durability

- Do You Sharpen Before The Last Cut?
 - Advantages of more complex steels lost
 - Removing valuable steel
 - Can get a sharper edge with M2

What About Carbide?

- Very Durable
 - Hard to sharpen
- Not Sharp
 - Low relief angle
- Brittle
 - Very little microstructure

Conclusions

- M2 for most turners
- M4 and PM-M4 best overall
- Complex alloys for continuous work or with highly abrasive materials (Teak, Rosewoods)
- Steels with high V, W and Mo are great for scrapers