MD™ & Hi-Hard™

Grade MD (P20 Mod with Nickel addition)
Grade Hi-Hard (MD to Higher Hardness)

Approximate chemistry equivalents:

EN 1.2311, 1.2330, DIN 40CrMnMo7, UNS T51620
EN 1.2738, DIN 40CrMnNiMo8-6-4

P20-type mold steel is well established as the basic alloy within the plastics molding industry for both injection and compression molding.

Beyond simply chemistry, however, steel-making procedures strongly influence mold steel performance. Procedures developed for melting, forging and heat-treating at Finkl have been shaped through decades of service and support to the plastics molding industry. The result is the very best mold steel available:

- Excellent machinability
- Great polishability
- Uniformity in texturing
- Excellent response to secondary processes (chromium plating, flame hardening)
- Durability for long-life molds

MD™ & Hi-Hard™
Nominal Chemistry (Wt.%)

0.33%	CARBON
0.80%	MANGANESE
0.45%	SILICON
0.40%	NICKEL
1.80%	CHROMIUM
0.45%	MOLYBDENUM
12.0	IDEAL DIAMETER*

*For more information, please refer to the **Finkl Mold Steel Handbook**.

Standard Hardness: MD

29-34 Rockwell C (HRC)
277-321 Brinell Hardness (HB)

This hardness range is suggested for most P20 applications where improved machinability, maximum dimensional stability and improved weldability are foremost requirements.

High Hardness: Hi-Hard

36-39 Rockwell C (HRC)
331-363 Brinell Hardness (HB)

Appropriate for compression molding applications, or molding with abrasive (fiber filled) compounds, or simply for anticipated long-run production. The higher hardness is also preferred for improved polishability.

Nominal Mechanical Properties for MD and Hi-Hard

GRADE	Hardness		Tensile Strength	Yield Strength	Elongation % in 2”	Reduction of Area % of .505”
	Rockwell C	Brinell				
MD	**29-34**	**277-321**	135,000 psi 931 MPa	115,000 psi 793 MPa	15.0	40.0
Hi-Hard	**36-39**	**331-363**	165,000 psi 1138 MPa	140,000 psi 965 MPa	12.0	30.0

Actual mechanical properties vary with test location and orientation within a block. Discuss your requirements with the Finkl metallurgical staff.

Suggested Cutter Speeds for MD and Hi-Hard Steel

		Suggested HSS Cutter Speeds for Milling MD & Hi-Hard				
Hardness	**HRC (HB)**	24 (248)	28 (269)	31 (293)	34 (321)	38 (352)
Surface Speed	**Meters/min**	85	76	67	58	50
	Feet/min	280	250	220	190	165

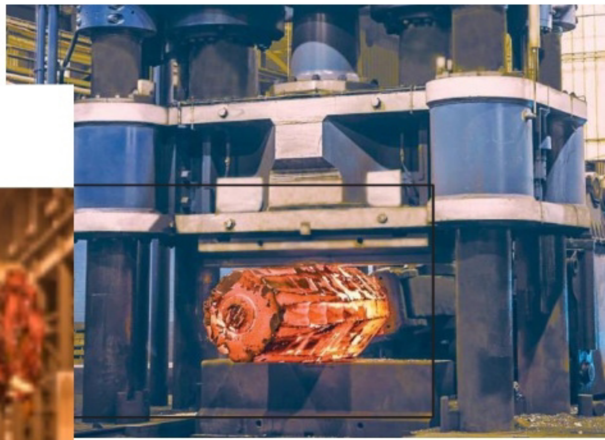
Carbide or coated tools may be expected to substantially increase these suggested milling speeds.

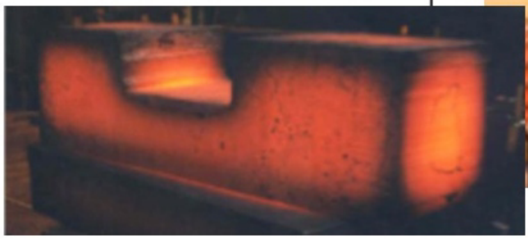
Melting | Mold Steel Grades MD & Hi-Hard: Electric Arc Furnace, Vacuum Argon Degassed

- **Deep Vacuum and Argon Stirring** during Ladle Metallurgy processing minimizes residual oxides for improved machinability and polishability.
- **Bottom-Pouring** during the critical ingot-teeming phase of manufacturing protects against re-oxidation and maintains the best possible steel quality.
- **Double Melted Mold Steel (Vacuum Arc Remelting, VAR)** The MD/Hi-Hard chemistry is available in double-melted quality, and is sold as grade MLQ (MD/Hi-Hard Chemistry for Lens Quality Molds). This offers the VAR advantage of refined grain size and improved alloy distribution for superior polishing response, and is recommended for diamond-polished molds.

Forging | Effective consolidation and refinement of ingot microstructure

Large blocks and custom shapes are available. The custom-forged block below is one example that was produced for an Automotive Fascia mold. The image to the far right is our 8,000 ton hydraulic forging press that provides effective consolidation and refinement of ingot microstructure.

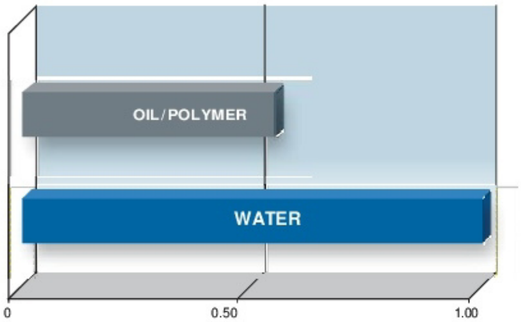




Heat Treating

The A. Finkl & Sons Co. practice of quenching with strongly agitated cold-water produces the best possible metallurgical microstructure and through-hardening effect.

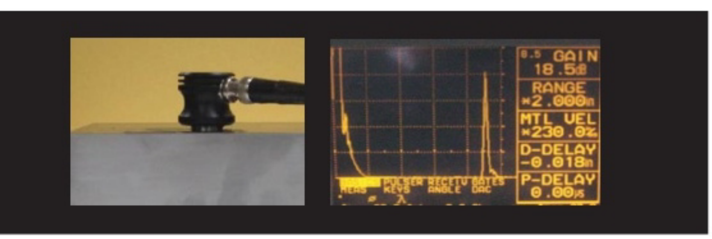
Relative Quenching Power:



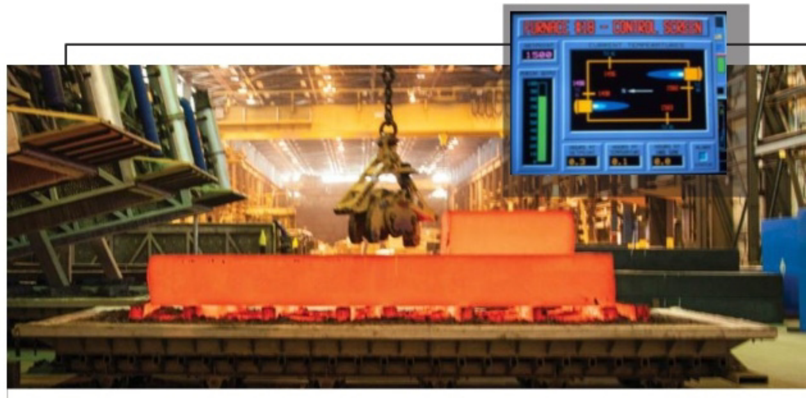
MD and Hi-Hard are sold in a pre-hardened, quenched and tempered condition, ready for machining. Stress relieving may be performed using the procedure supplied under Welding (Step 3).

Localized hardening using *Flame Hardening* procedures may be expected to provide a surface hardness of 50+ Rockwell C, depending upon the procedure used. *Flame Hardening* generates high thermal and transformational stresses, raising some risk of cracking.

Ultrasonic Inspection



All Finkl mold blocks are 100% ultrasonically inspected by ASNT-TC-1A qualified inspectors according to the latest ASTM A-388 or EN 10228-3 procedures. Stringent internal Acceptance/Rejection criteria provide confidence to moldmakers that Finkl blocks are the highest possible quality.



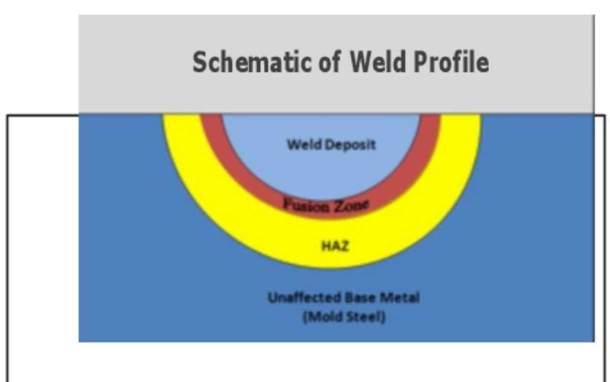
Welding

Though welding without pre-heating and post-weld stress relieving has been successful at times, especially with minor laser welding, a thermal practice is recommended to avoid a hardened Heat Affected Zone that may cause subsequent polishing, etching or cracking issues.

1. Preheat the entire mold to 600°F-800°F (316°C – 427°C). Hold for approximately ½-hr per inch of thickness. The heating *rate* should be moderated, especially for large molds, to avoid excessive thermal gradients and stresses.
2. Perform welding while maintaining 400°F (200°C) minimum temperature.
3. Immediately upon completion of welding, place the mold into a furnace, and heat to a stress relieving temperature of:
   - For **MD** (29-34 HRC) - 1080°F (580°C). Hold ½-hour per inch of thickness.
   - For **Hi-Hard** (36-39 HRC) - 1020°F (550°C). Hold ½-hour per inch of thickness.

These temperatures and times also apply to general stress relieving, for example, after extensive machining. Furnace control is essential to avoid overheating and consequent loss of some base hardness.

Selection of a welding rod should be discussed with a welding rod supplier since the purpose of the weld, e.g., alloy matching, hard facing, ductile tack welding, etc., will dictate the appropriate rod type or composition.



Polishing

Successful polishing requires talent, patience and experience. But some known basics are:

- Practice extreme cleanliness between steps to avoid carryover of contaminant particles
- Use high quality consumables
- Follow a reasonable abrasive progression. A suggested sequence is:

Grit	180	240	320	400	600
µm	80	60	35	20	8

Departing from well established basic procedures and failing to fully complete each step is a common source of disappointing results.

Texturing

Mold steel with excellent microstructural uniformity, together with proper application of the “resist” pattern and careful control of acid activity are essential to success. Additional requirements for achieving texturing uniformity are:

- Stress Relieve prior to texturing, particularly for molds with EDM or welded areas. Locally hardened areas from welding (HAZ) or EDM may respond differently to acid attack compared to adjacent base-metal.
- Maintain the same grain flow direction, and same parent material, if possible, for molds, composed of inserts or for molding of mating components.

Chromium Plating

Challenges to the chrome plating process include careful maintenance of the plating solution for cleanliness, appropriate Cr-ion concentration, deposition rates and electrode design. High quality steel is important to minimize the presence of non-metallic (and non-conductive) inclusions in the steel that, intersecting the surface, are accentuated by the plating process. The source of plating pits, however, is difficult to resolve without destructive testing.

An example, in cross-section, of chrome-plated MD showing pits originating within the plating process.

Physical Properties

Test Temperature	68˚F/20˚C	390˚F/200˚C	750˚F/400˚C
Density	7800 Kg/m³	7750	7700
	0.282 lbs/in³	0.280	0.277
Coefficient of Thermal Expansion	$11.9x10^{-6}$ cm/cm/˚C	$12.7x10^{-6}$	$13.6x10^{-6}$
	$6.6x10^{-6}$ in/in/˚F	$7.0x10^{-6}$	$7.5x10^{-6}$
Thermal Conductivity	28.0 J/m²/m/s/˚C	29.5	31.0
	202 BTU/ft²/in/hr/˚F	205	216
Modulus of Elasticity	$205x10^{3}$ N/mm²	$200x10^{3}$	$185x10^{3}$
	$29.7x10^{6}$ lbs/in²	$29.0x10^{6}$	$26.8x10^{6}$
Specific Heat	460 J/Kg ˚C	492	538
	0.110 BTU/lb˚F	0.118	0.129
Poisson’s Ratio	0.3	0.3	0.3

FINKL PARTNER PROGRAM℠

A. Finkl & Sons, Co. offers select customers the opportunity to participate in the Finkl Partner Program, a Web-based system that allows for:

- online quoting and ordering
- real-time order tracking
- customized report generation

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