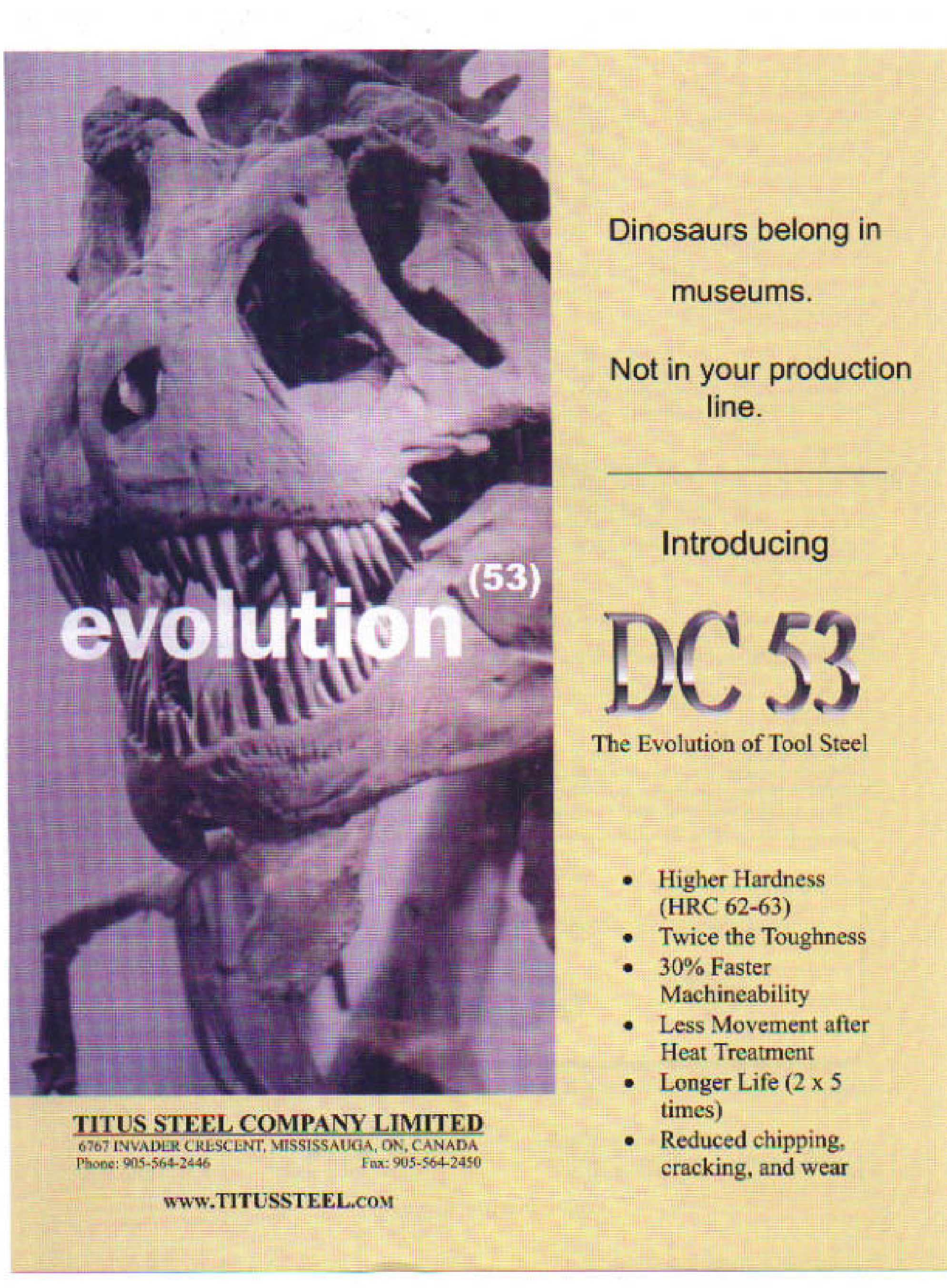
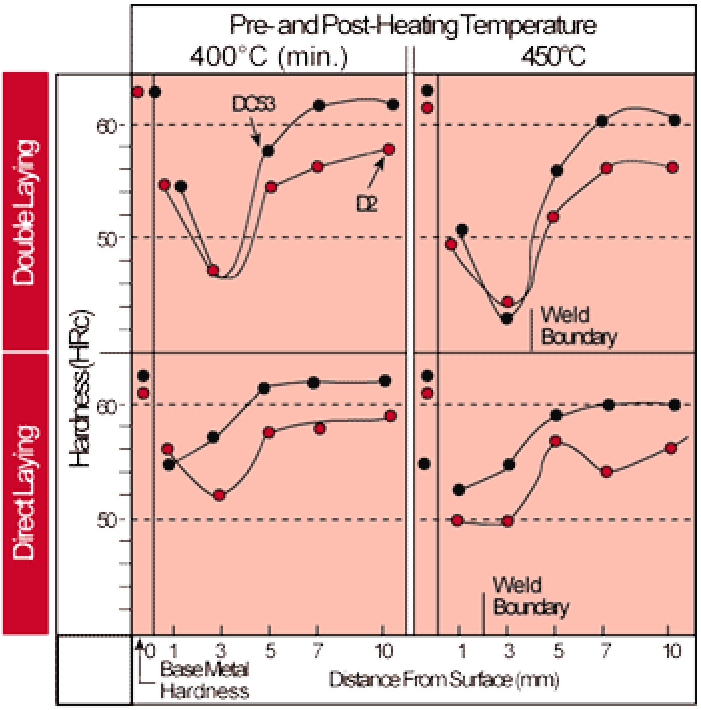
DC53	DC53 is a general-purpose cold work die and mold steel whose strength and toughness approach those of high-speed steels

THE FIRST NEW GENERAL PURPOSE TOOL STEEL IN 50 YEARS





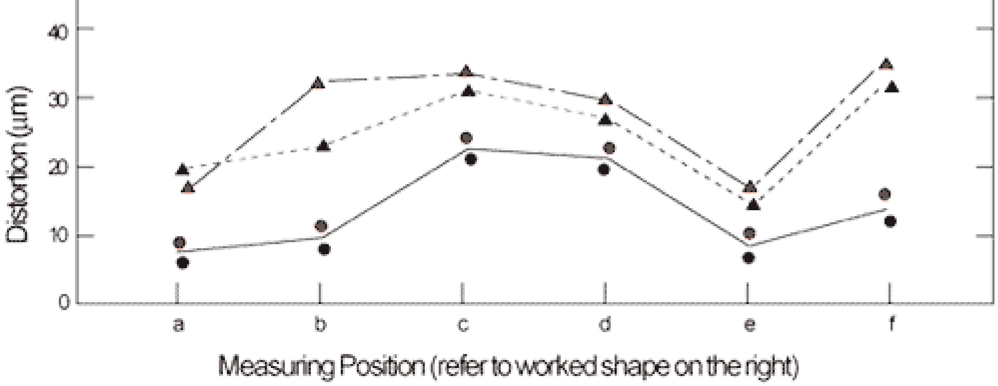
Hardness Distribution in Cross-Section Area of Built Up Weld

Designation	Chemical composition (Wt%)
DF-38 (JIS Z3251)	C: 0.20/0.50, Si:≤3.0, Mn:≤3.0 Cr: 3.0/9.0, Mo:≤2.5, P,S:≤0.03

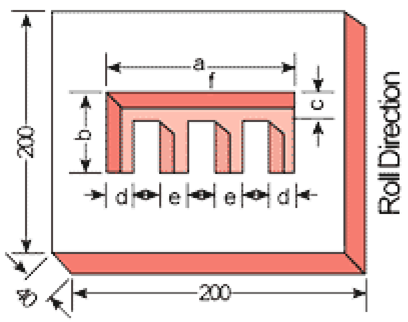
Machining/Grinding
Machines and grinds better and faster than D2 for longer tool life and reduced tool manufacturing time.

EDM
Residual stress caused by quenching is minimal in DC53. Therefore, problems such as cracking and distortion are prevented during and after wire electro-discharge machining.

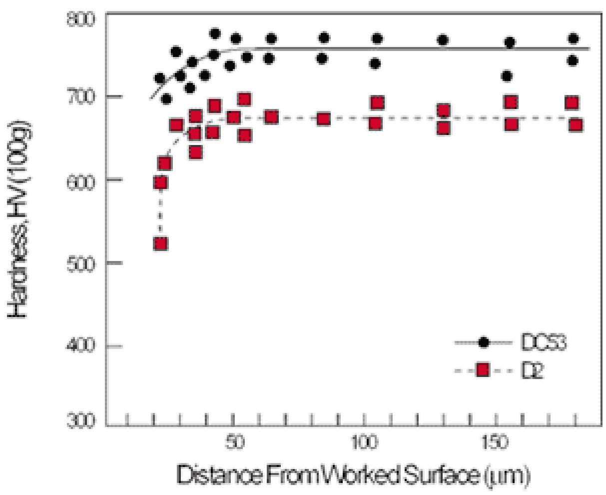
		Quenching	Tempering	Hardness(HRc)
DC53	●	1030°C x 2hr vacuum gas-cooled	520°C x 3hr, 520°C x 3hr air-cooled	62.6
	●	1030°C x 2hr vacuum gas-cooled	530°C x 2hr, 520°C x 2hr air-cooled	62.2
D2	▲	1030°C x 2hr vacuum gas-cooled	530°C x 2hr, 520°C x 2hr air-cooled	58.0
	▲	1030°C x 2hr vacuum gas-cooled	Sub-zero (-80°C) 180°C x 3hr	61.2



Relationship Between Heat Treatment Conditions
and Distortion After Wire Electro-Discharge Machining



Test Piece Shape
(Worked Dimensions)
a = 140.00 mm
b = 62.5
c = 20.0
d = 20.0
e = 17.0
f = starting hole = 0



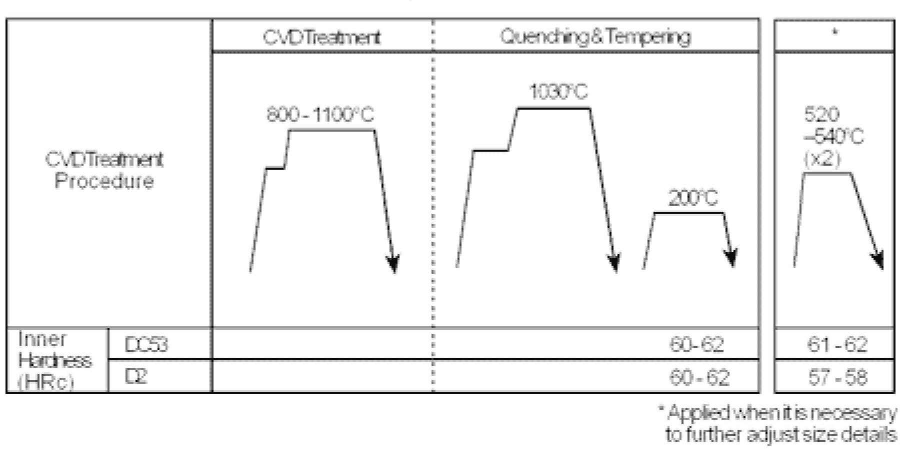
Hardness Distribution in Area Affected by Electro-Discharge Machining

Sub-surface hardness decline of DC53 just below wire electro-discharge machining is much less than D2; thus making DC53 dies more durable.

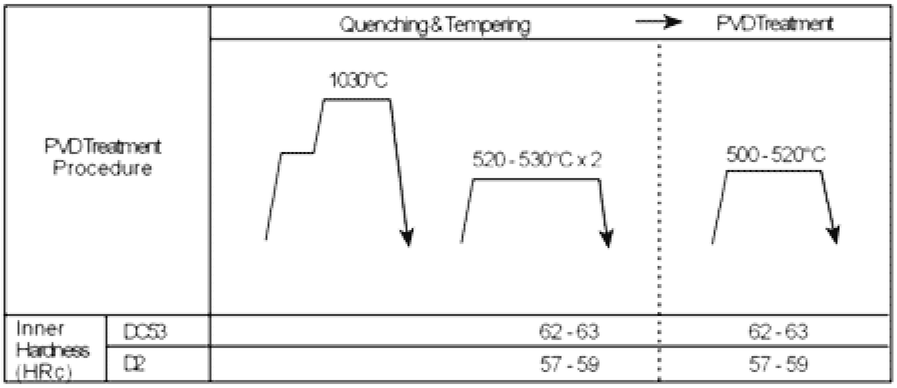
Stability
High-temperature tempering (520°C) allows maintenance of die accuracy without the troublesome application of subzero treatment, reducing costs and increasing productivity.

Surface Enhancements
Surface hardening treatments such as CVD, PVD, TD, and nitriding require the use of high temperatures. DC53's higher inner hardness than D2 after such treatments, preventing the hardened layer from peeling off and making surface hardening treatments more effective.

Inner Hardness Changes Due to CVD Treatment



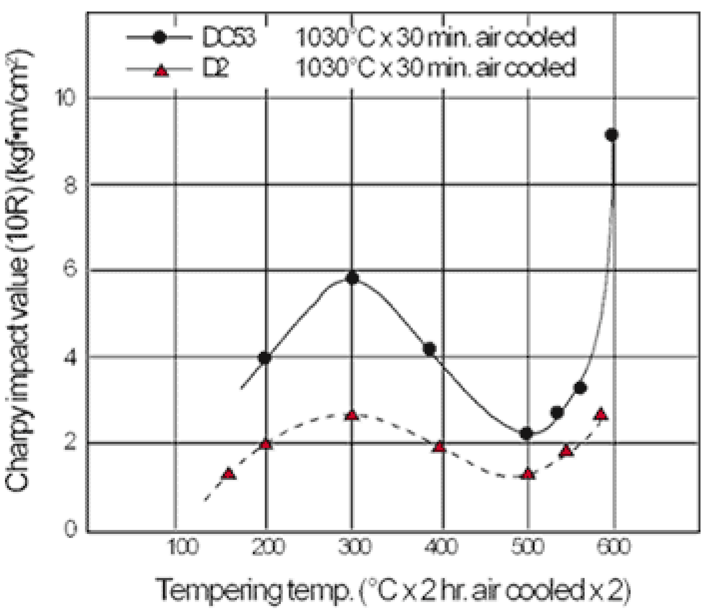
Inner Hardness Changes Due to PVD Treatment



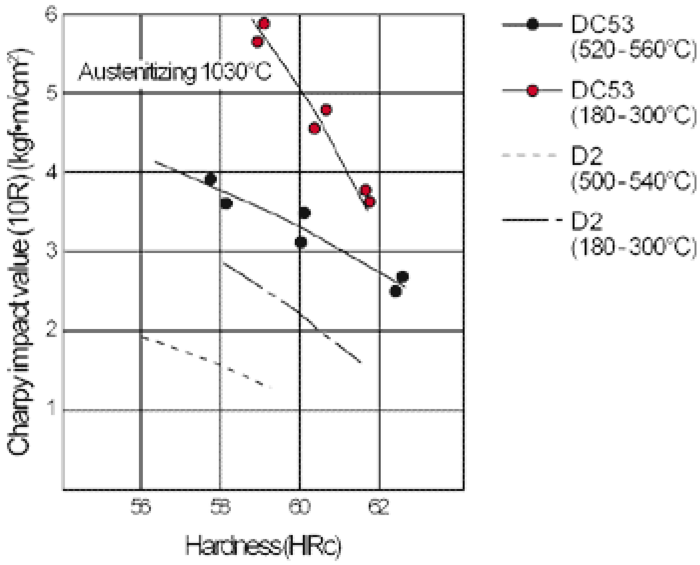
Wear
Superior wear-resistance coupled with high toughness make DC53 suitable for use in wear-resistant parts subject to impact and bending stress.

Strength
Dies made of DC53 and heat-treated using standard method possesses up to 25% higher bending strength than D2. Secondary refining decreases nonmetallic inclusions and carbide size for a 20% increase in fatigue strength over that of D2.

Toughness
Superior impact value minimizes fracture and chipping problems thus ensuring more durable dies.



Relationship Between Tempering Temperature and Impact Value



Relationship Between Hardness and Impact Value

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PHYSICAL PROPERTIES

Coefficient of Thermal Expansion (x10-6/C°)

	~100° C	~200°	~300°	~400°	~500°	~600°	~700°
DC53	12.2	12.0	12.3	12.8	13.2	13.4	13.0
Annealed							

Coefficient of Thermal Conductivity (cal/cm·sec°C)

	Room Temp.	100°C	200°	300°	400°	500°	600°
DC53	0.057	0.060	0.064	0.064	0.065	0.062	
Quenched and Tempered							

Specific Gravity (g/cm3)	7.87
Young's modulus (E)	21,700
Modulus of Rigidity (G)	8,480
Poisson's Ratio (v)	0.28

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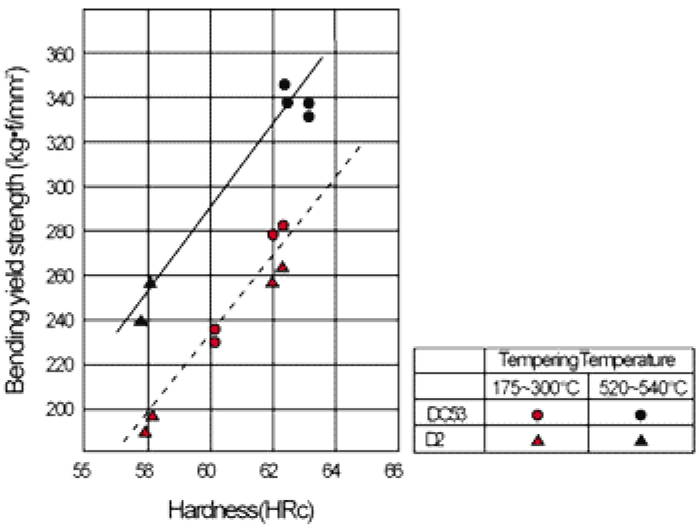
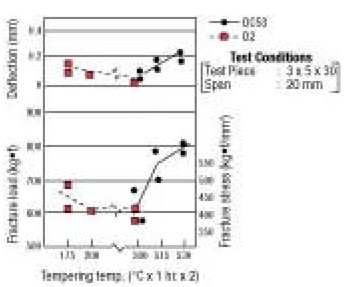
GENERAL DESIGN GUIDELINES

Strength
DC53 high hardness (HRc62) coupled with standard methods of heat treating result in

superior bending strength, up to 25% higher than D2. Ideal for dies to form high tensile steel plates and other heavy-thickness steel plates and cold forming tools undergoing high loads such as dies for bending and cold forging.

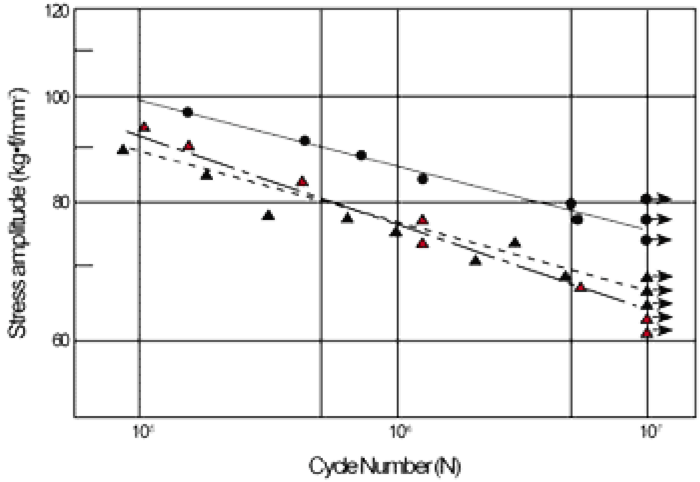


Relationship Between Hardness
and Bending Yield Strength



Relationship Between Tempering Temperature and Bending Fracture Strength

A secondary refining process minimizes the size of carbides and decreases nonmetallic inclusions for a 20% increase in fatigue strength over D2. This characteristic makes DC53 suitable for use where repeated stresses are loaded, such as precision-punching dies with small clearance and cold forming tools. DC53 is particularly suited to handling less-workable materials such as stainless and heat-treated alloy steels.

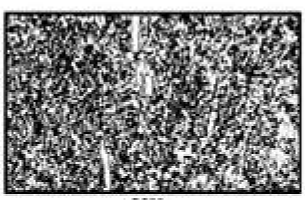


Rotating Bending Fatigue Strength

—●— DC53
Heat treatment 1030°C, 520°C (x2), HRc63

—▲— D2
Heat treatment 1030°C, 520°C (x2), HRc59

- -▲- - D2
Heat treatment 1030°C, 200°C), HRc61

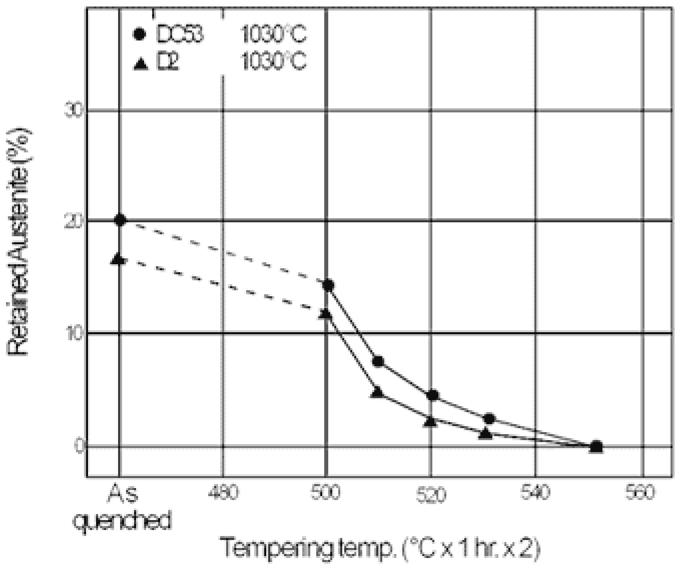


DC53

D2

Stability

Dimensional changes of dies in operation are caused mainly by decomposition of retained austenite. High-temperature tempering (520° to 530°C) reduces the presence of austenite to 5% or less, providing the same effect as the troublesome application of subzero treatment. This reduction in retained austenite makes DC53 particularly suitable for precision dies and gauges where dimensional changes during operation must be minimized.



(Reference)

Changes in retained austenite percentage in D2 resulting from sub-zero treatment

1030°C air cooled as quenched	18.5%
-80°C sub-zero treated	3.8%

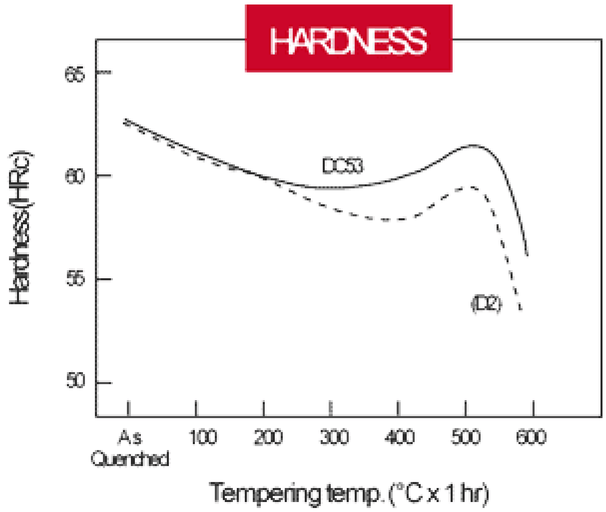
Relationship between tempering temperature and amount of retained austenite

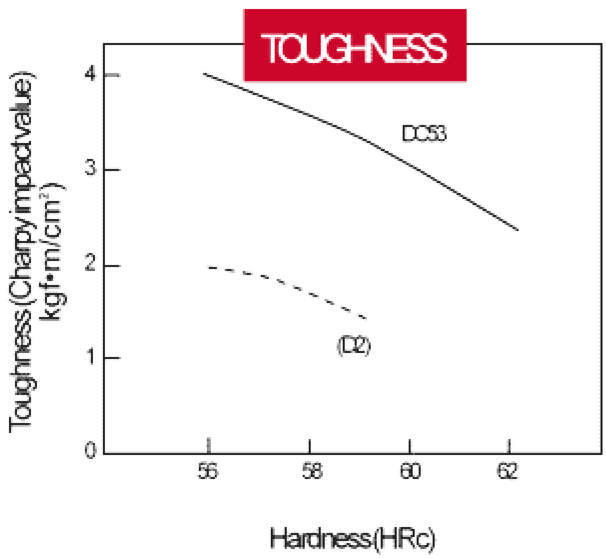
---

Note: As with any cold work die steel, when dealing with close tolerance parts and tempering at the high tempering temperature, it is necessary to temper a third time @ 400°C. This helps to minimize the occurrence of grain growth and distortion that may occur weeks or even months after heat treat.

Hardness

DC53 can be hardened to 62-63 HRc in the same manner as D2, and when tempered at high temperatures (520° to 530°C), it assumes excellent properties. Even when tempered at lower temperatures (180° to 200°C), its performance is equivalent to or better than that of D2. This improved hardenability makes heat treatment easier and reduces hardness problems due to vacuum heat treatment, which uses gas cooling.





Smaller primary carbides give DC53 twice the toughness of D2

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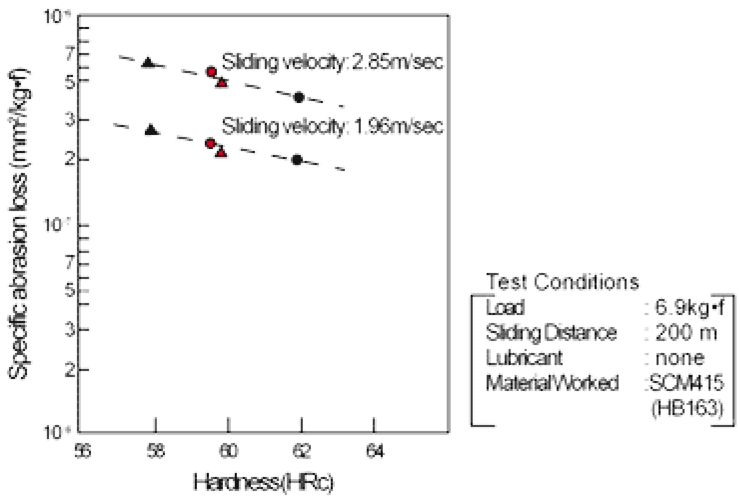
WEAR PROPERTIES

DC53 displays superior wear-resistance to D2 when tempered at high temperatures (520°C) and equal wear resistance to D2 when tempered at low temperatures. High resistance to temper softening minimizes seizing and galling on the die surface. DC53 is ideal for dies needing to maintain high surface hardness against frictional heat between the die surface and the worked materials.



Abrasion Test (Ohgoshi method)

● DC53 : 1030°C oil-cooled, 530°C air cooled X 2
● DC53 : 1030°C oil-cooled, 200°C air cooled X 1
▲ D2 : 1030°C oil-cooled, 520°C air cooled X 2
▲ D2 : 1030°C oil-cooled, 200°C air cooled X 1

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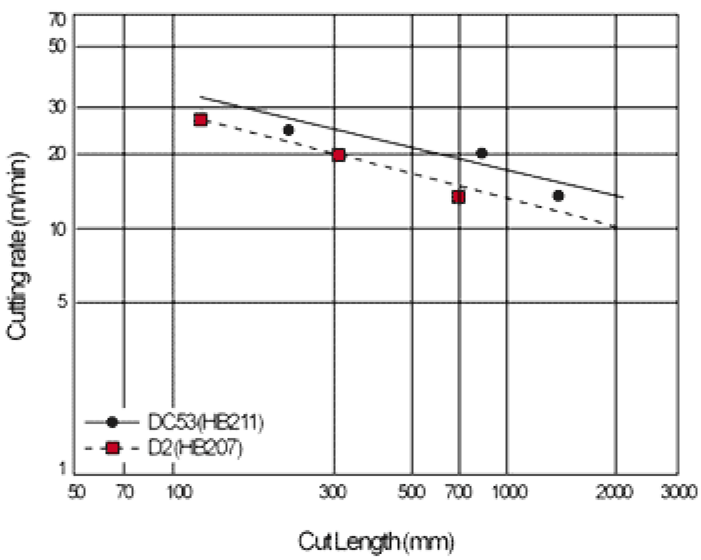
PROCESSING GUIDELINES

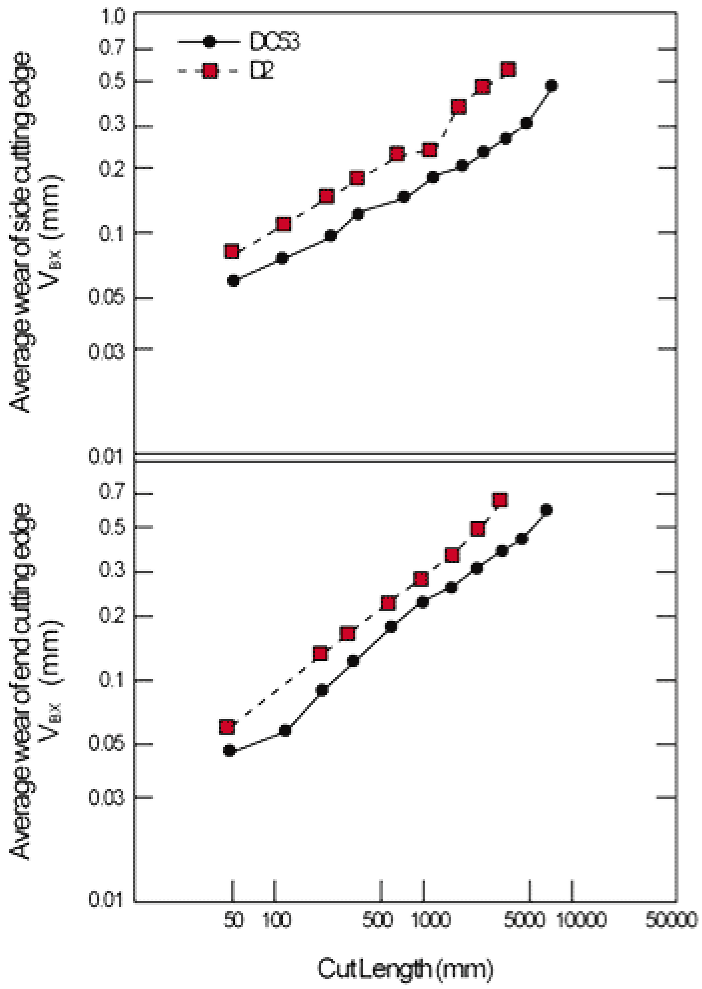
Machining and Grinding
DC53 contains perfectly spheroidized primary carbides. Therefore, it is superior in machinability and grindability to D2. Its grindability, in particular, is 30 to 40% better than that of D2 and facilitates grinding of thin tools and accurate sizing of die detail. In addition, since DC53 is tempered at high temperatures, there is little possibility of grinding cracks and the number of processes required for die manufacture can be reduced.



Durability of Drilling Tool

Test Conditions

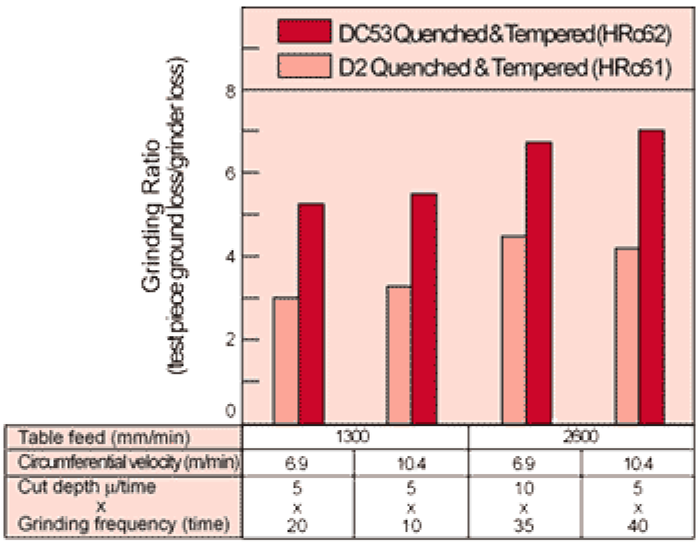
Tool	: SKH51, Ø10 taper shank drill α=118°
Feed	: 0.15 mm/rev.
Hole Depth	: 30 mm (blind hole)
Cutting Fluid	: none
Durability Criterion	: too failure



Durability of Face Cutting Tool

Test Conditions

Cutter	: TDG4406R (Ø160)
Chip	: SDCN42ZTN (UX30)
Number of Chip	: 1
Feed	: 27 mm/min 0.1255 mm/blade)
Cut Depth	: 215 RPM (108 m/min)
Method of Machining	: center cut
Cutting Fluid	: none (dry process)



Comparison of Grindability (centerless grinding)

Grinding Conditions

Grinding Wheel	: WA120, Ø405 X 30t
Circumferential Velocity of Wheel	: 2700mm/min. (2120 RPM)
Grinding Fluid	: water soluble
Size of Test Piece	: ø22 x 200

Hardness decline due to grinding heat is also prevented, thus raising die performance.

EDM

In order to perform highly accurate wire electro-discharge machining, it is recommended that high-temperature tempering (520°C or higher) be conducted twice to minimize heat treatment residual stress. Reduction of residual stress is insufficient if applying subzero treatment and repeated tempering at low temperatures. In order to avoid deceleration of machining speed, rust formation, and galvanic corrosion, the following procedures are recommended.

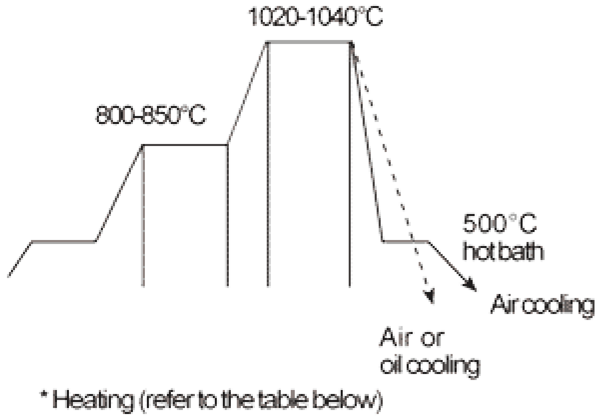
1. Make the machining fluid spray pressure as high as possible and place the upper and lower nozzles close to the material to be worked in order to smoothly wash away the sludge formed on the machined surface. This is especially necessary for machining heavy-walled materials.
2. Maintain specific resistance of machining fluid at an appropriate value. If the specific resistance falls (electric conductivity of machining fluid rises), galvanic corrosion and deterioration of the layer tend to occur due to the influence of electrolization.
3. In addition to the above, consider use of a rust-preventive agent to prevent rust and adoption of the immersion process (which prevents the machined surface from coming into contact with the air and oxidizing).

Heat Treating

Standard heat treatment conditions are shown in the diagrams and tables below. As shown in the CCT curve graph, DC53 is superior in hardness to D2 and can be quenched sufficiently by air or gas cooling in a vacuum furnace. DC53 and D2 require the same austenitizing temperatures (1,020 – 1,040°C) and can be heat-treated at the same time. High temperature tempering (520°C or higher) allows DC53 to retain its high hardness and wire electro-discharge machinability. Even when tempered at low temperatures (180-200°C), DC53 remains twice as tough and equal or higher in hardness (wear resistance) than D2.

Usual Quenching

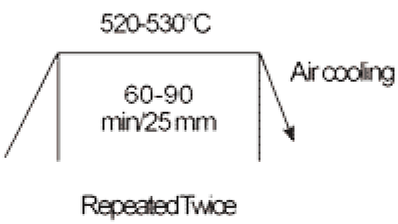
QUENCHING



Standard heating time (salt bath)

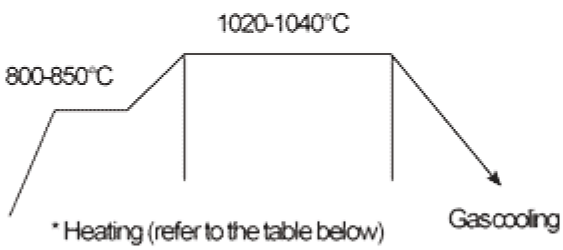
Dia. Thickness (mm)	Immersing Time (min)
5	5 - 8
10	8 - 10
20	10 - 15
30	15 - 20
50	20 - 25
100	30 - 40

TEMPERING



Vacuum Quenching

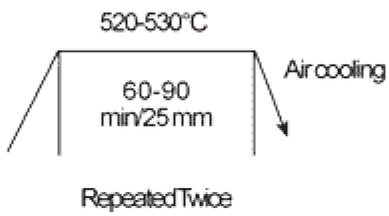
QUENCHING

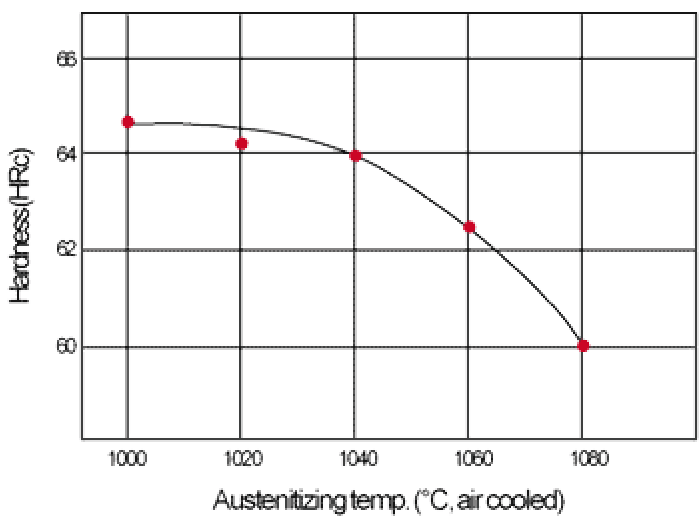


Standard heating time

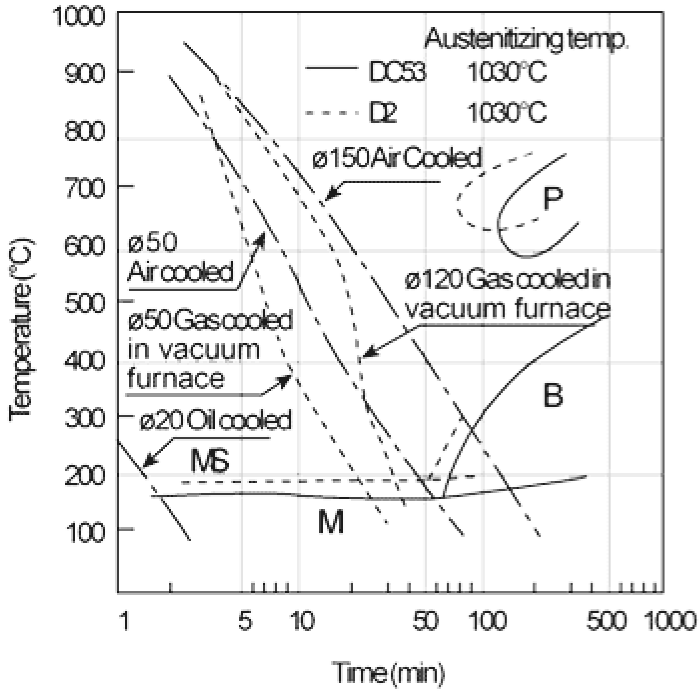
Thickness (mm)	Heating Time
100mm and under	20-30 min./25mm
Over 100mm	10-20 min./25mm

TEMPERING

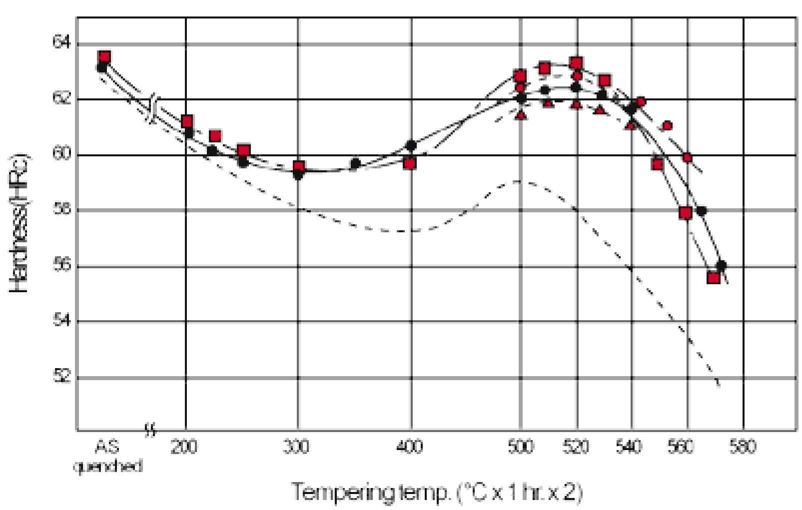




Quenching Hardness Curve



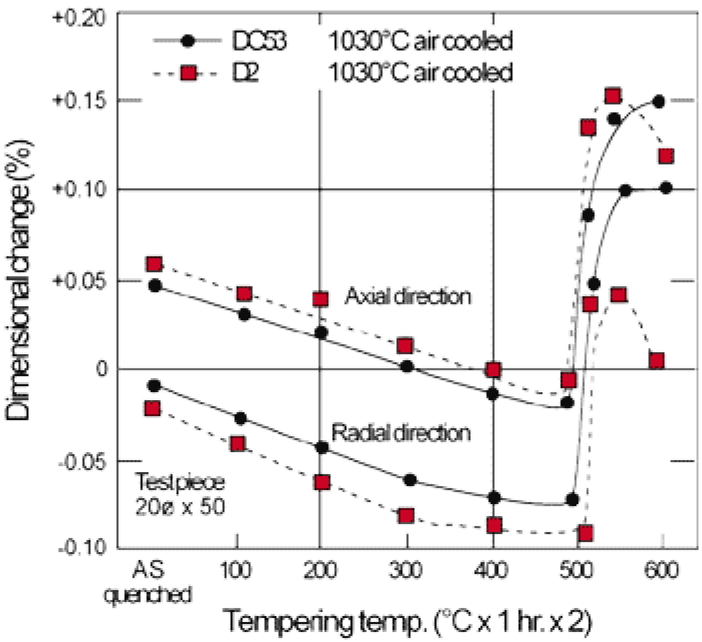
CCT Curve



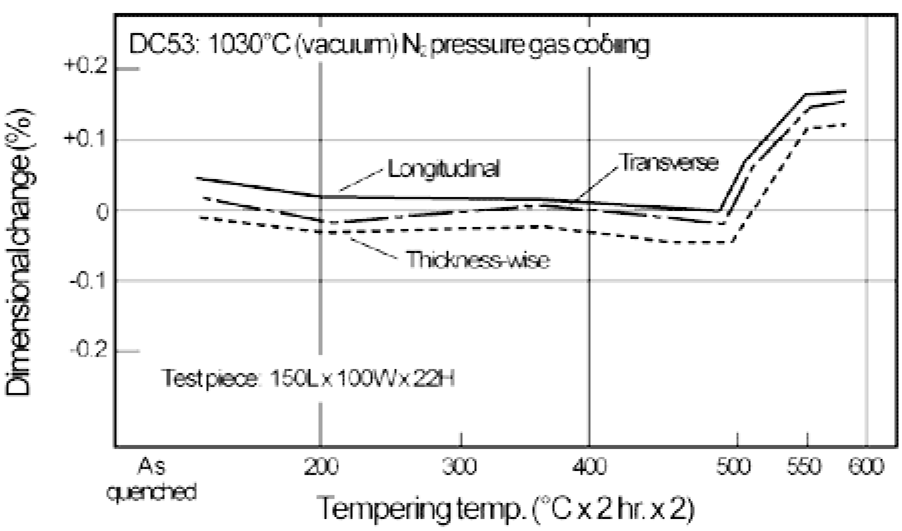
Tempering Hardness Curve

DC53 1040°C Air cooled
DC53 1030°C Air cooled
DC53 1020°C Air cooled
DC53 1040°C Oil cooled
D2 1030°C Air cooled

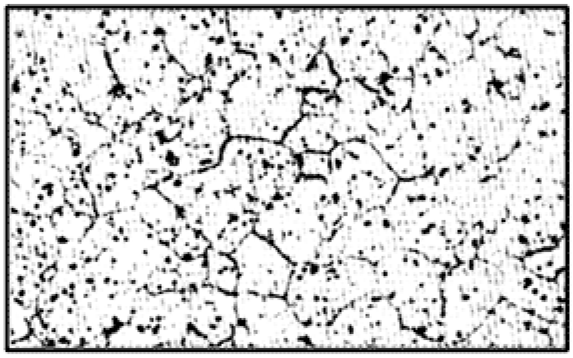
Dimensional changes due to heat treatment.



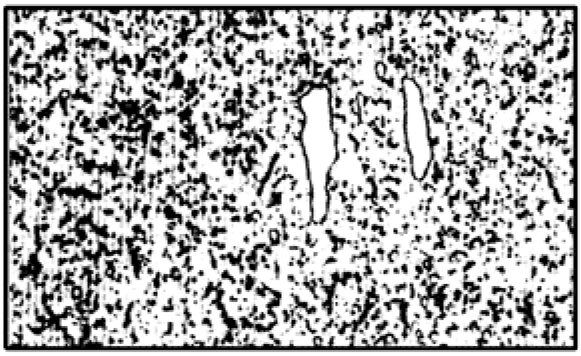
Basic Data



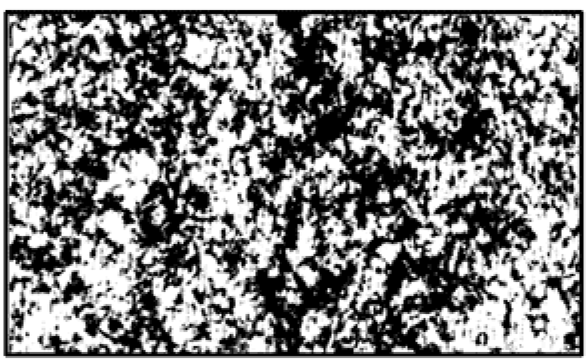
Block Example



1030°C air cooled x400



Low temperature: 200°C x 1 x400



High Temperature: 520°C x 2 x400

Recommendations on Heat Treatment

Heating procedure in quenching and tempering is basically identical for both DC53 and D2. However, the conditions outlined below are recommended according to use and purpose.

Heat Treatment Temperature According to Use and Purpose

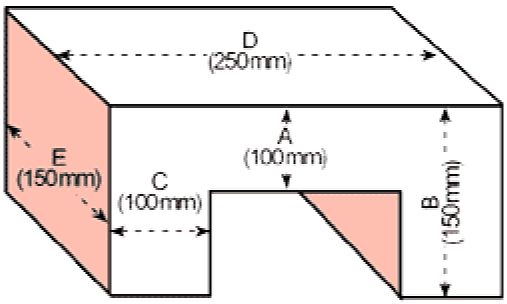
Use, Purpose	Heat Treatment Temperature (°C)		Hardness used (HRc)
	Quenching	Tempering	

Dies where galling and seizing resistance are important: 1. High tensile steel sheet forming die 2. Deep drawing, die 3. Cold forming die ✍ Cold forging punch, die ✍ Thread-rolling die 4. Thick plate bending die	1,030 to 1,040	520 to 530 (x2)	62-63
Tools and Jigs required to have high toughness: 1. Metal blade to handle comparatively thick (>1mm) plate ✍ Shear blade, slitter 2. Slender punch	1,010 to 1,020 1,020 to 1,030	530 to 540 (x2) 200 to 300 (x2)	57-60 58-61
Cases where secular dimensional change is important (elimination of subzero treatment) 1. Precision die, gauge	1,020 to 1,030	520 to 530 (x2) & 400 (x1)	61-63

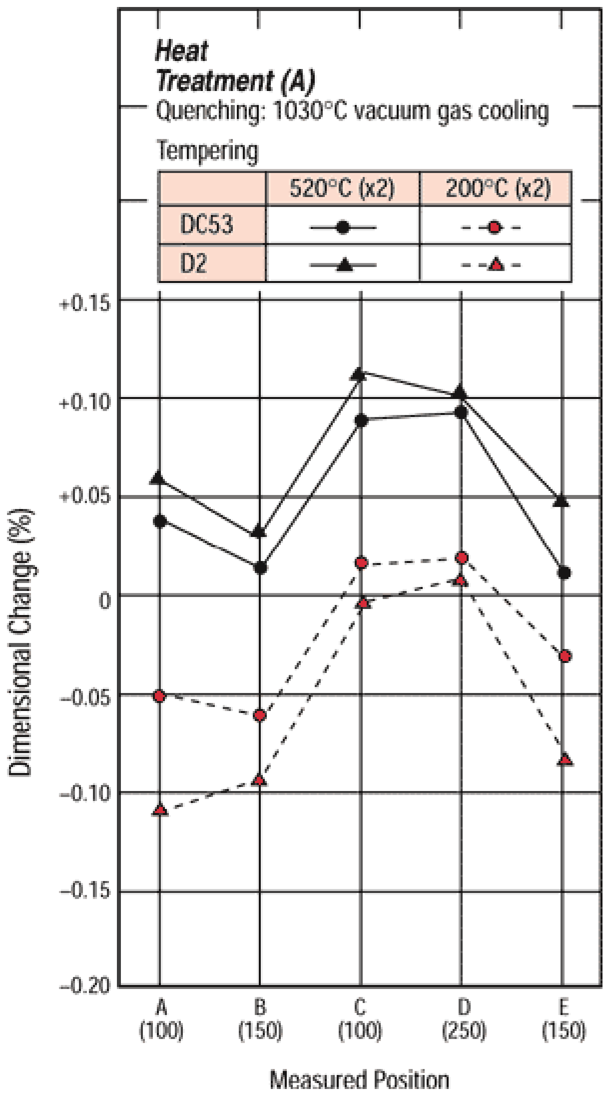
Note: Double high-temperature tempering is absolutely necessary. In high-temperature tempering accompanying the decomposition of retained austenite, so-called fresh martensite is formed, causing toughness to deteriorate. (This is most likely to occur in the temperature range between 450° and 510°C). This deterioration may cause chipping and cracking and it is necessary to recover toughness by carrying out secondary tempering.

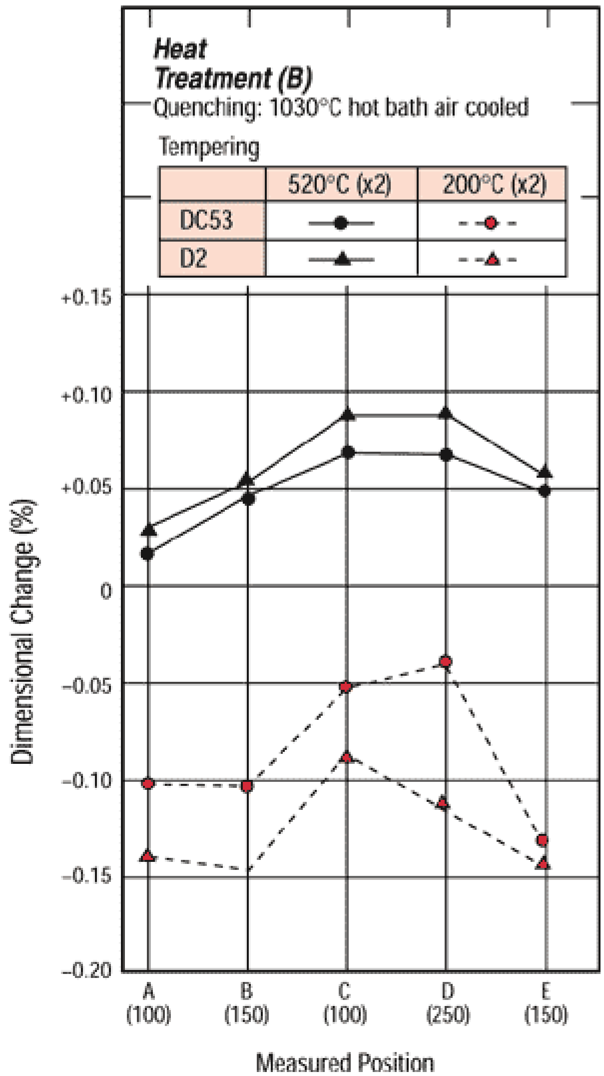
Note: As with any cold work die steel, when dealing with close tolerance parts and tempering at the high tempering temperature, it is necessary to temper a third time @ 400°C. This helps to minimize the occurrence of grain growth and distortion that may occur weeks or even months after heat treat.

Dimensional Changes due to Heat Treatment of a Shaped Block



Shaped Block Dimensions (mm)





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DIE APPLICATIONS

Blanking dies for electric home appliance components

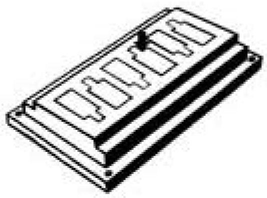
Application:
Blanking dies for Ni based alloy materials used for medium-scale production of television components.

Results

Working	Material Worked	Conventional die steel	DC53	Approx. dimensions (mm)
Cold pressing	Ni-based alloy (0.2 mmt)	D2 HRc58/59 Tempered at 510°C	HRc62/63 Tempered at 510°C	35tx100Wx250L

Evaluation	5,000S	25,000S	5 times

Considerations



Conventional Steel–The worked material is tough and chipping and seizing of the die edge were problematic.

DC53–Both high temperature tempering and high hardness are important in preventing seizing and extending the life of the die edges. High hardness, when tempered at high temperature, and homogeneous structure of DC53 were greatly effective in meeting these requirements.

FB punches for electric appliance components

Application
FB punches for hook-shaped electric appliance components. Long, thin shape promotes severe conditions.

Results

Working	Material Worked	Conventional die steel	DC53	Approx. dimensions (mm)
Fine blanking	1045 (HRB80 1.5 mmt)	D2 HRc56 Tempered at 530°C	HRc60 Tempered at 550°C	70ø x 110L
Evaluation		1,600S	3,900S	2.4 times

Considerations

Conventional Steel–Cracking and fracturing at the tip of the long, thin shape, shortened life.

DC53–Because of DC53's excellent toughness, hardness could be increased, resulting in more than double the life.

Plastic molds for electric appliance components

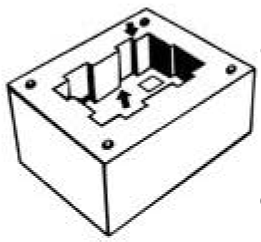
Application
Injection molds for electromagnetic switch boxes. Since the material worked is FRP resin, wear in the area surrounding the gate is particularly problematic.

Results

Working	Material worked	Conventional die steel	DC53	Approx. dimensions (mm)

Injection molding	ABS-FRP resin (25% filler)	D2 HRc59 Tempered at 510°C	HRc63 Tempered at 520° C	90tx150Wx250L
Evaluation		4,500S	26,000S	5.8 times

Considerations



Conventional Steel–The mold was discarded due to wear occurring in areas surrounding the gate and where the flow of resin became irregular.

DC53–Applying the highest hardness of DC53 (HRc63) proved highly effective in combating simple wear.

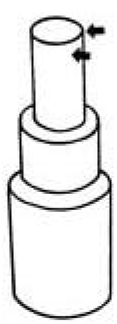
Cold forging punches for electric instrument components

Application
Working of bushings by backward extrusion.

Results

Working	Material worked	Conventional die steel	DC53	Approx. dimensions (mm)
Cold forming	1020 (8mmø)	D2 HRc59 Tempered at 510°C	HRc62/63 Tempered at 510°C	17øx80L
Evaluation		20,000S	65,000S	3.2 times

Considerations



Conventional Steel–Wear of punch edge and galling lateral face shortened durability.

DC53–To prevent wear and galling, hardness of DC53 was tempered at a high level, resulting in expected extension of life (due to its high toughness, this material resists cracking.)

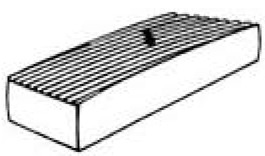
Flat thread rolling dies

Application
Flat thread rolling dies for working stainless steel bolts where there is a particularly high working load.

Results

Working	Material worked	Conventional die steel	DC53	Approx. dimensions (mm)
Thread rolling	SS304 (5mmø)	D2 HRc60 Tempered at 500°C	HRc62/63 Tempered at 530°C	40tx80Wx190L
Evaluation		3,800S	21,000S	5.5 times

Considerations



Conventional Steel–Chipping and local seizing of threads, required early regrinding.

DC53–In working with stainless steels, high toughness, high hardness, and high resistance to temper softening are necessary. DC53 proved effective.

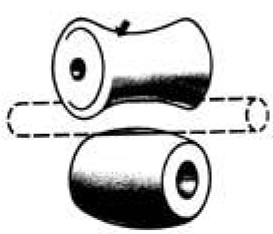
Rolls for straightening machines

Application
Straightening of heat-resistant steel and stainless steel where pitting of the roll is a major problem and high hardness and toughness are required.

Results

Working	Material worked	Conventional die steel	DC53	Approx. dimensions (mm)
Straightening	SS400 Series (8-10mmø)	D2 HRc58 Tempered at 510°C	HRc61/62 Tempered at 510°C	200øx280L
Evaluation		12Ton	50 Ton	4 times

Considerations



Conventional Steel–Pitting of roll surface and local seizing occurred, terminating life.

DC53–The basic characteristics of DC53 fully met the requirements for high toughness to prevent pitting and high hardness to prevent seizing.

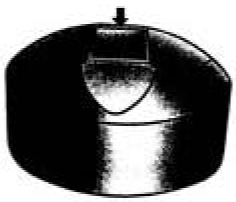
Trimming dies for bolt (hexagonal)

Application
This type of die is commonly used. Surface hardness treatment is applied depending on the material worked and the precision of the finish required.

Results

Working	Material worked	Conventional die steel	DC53	Approx. dimensions (mm)
Trimming	5140 (HRc23 16mmØ)	Semi-high speed steel HRc60 CVD-treated	HRc62/63 Tempered at 520°C CVD-treated	48Øx35L
Evaluation		11,000S	42,000S	3.5 times

Considerations



Conventional Steel–Chipping of the cutting-edge and insufficient base hardness of the die led to termination of life.

DC53–To increase the effectiveness of surface treatment, higher base hardness of the die should be considered. High hardness of DC53 proved effective.

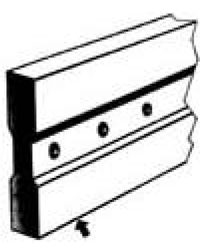
Shear blades for steel sheet

Application
Shear blades to slit all types of steel sheet, particularly high-tensile steel sheet or thick plate where chipping of the blade edge is problematic.

Results

Working	Material worked	Conventional die steel	DC53	Approx. dimensions (mm)
Shearing	High-tensile steel sheet (1.3mmt)	D2 HRc61 Tempered at 200°C	HRc62 Tempered at 530°C	30tx180W x2,100L
Evaluation		11 days	27 days	2.5 times

Considerations



Conventional Steel–In the first stages of use, chipping of blade edge occurred marking the beginning of blade wear.
DC53–High toughness of DC53 was effective in reducing chipping, while high-temperature tempering provided resistance to temper softening of the blade edge,thus increasing durability.

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