Application Range

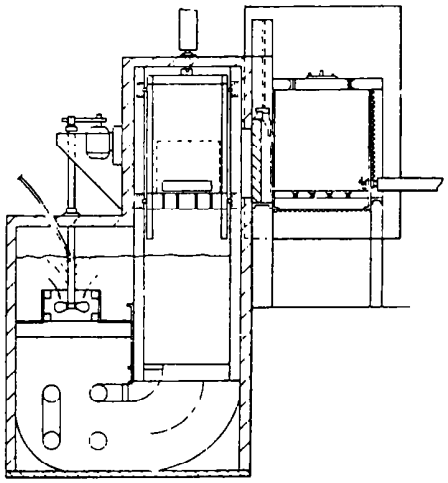
Molten salt quenching applications include:

- Martempering and austempering (see items on both subjects in this chapter)
- Quenching high-alloy steels
- Quenching high-speed steel tools, to minimize scaling, distortion, and cracking
- Quenching steels such as spring wire to reduce the risk of cracking during martensitic formation
- Quenching to enhance the formation of high-temperature transformation products, such as bainite and ferrite.

Reference

1. Totten et al., *Handbook of Quenchants and Quenching Technology*, ASM International, 1993

Dual impeller salt bath agitation system



Brine Quenching Process

The term refers to aqueous solutions containing different percentages of salts such as sodium chloride (NaCl) or calcium chloride (CaCl).

Characteristics

Cooling rates are higher than those of water for the same degree of agitation, or, alternately, less agitation is needed to get a given cooling rate. Higher cooling rates reduce the possibility of steam, the cause of soft spots in quenching, but higher cooling rates generally increase the likelihood of distortion and cracking. Use of baffling patterns on quench tanks and propeller agitation may be needed in quenching very lower hardenability steels (Ref 2).

In quenching, minute salt crystals are deposited on the surfaces of workpieces. Localized high temperatures cause crystals to fragment violently, creating turbulence that destroys the vapor phase, resulting in very high cooling rates.

Relation of Brine Density to Brine Concentration (Ref 2)

Salt, %	Specific gravity: Direct reading hydrometer	Specific gravity: °Bé(a)	Salt concentration: g/L	Salt concentration: lb/gal
NaCl solutions				
4	1.0268	3.8	41.1	0.343
6	1.0413	5.8	62.4	0.521
8	1.0559	7.7	84.5	0.705
9	1.0633	8.7	95.9	0.800
10	1.0707	9.6	107.1	0.894
12	1.0857	11.5	130.3	1.087
NaOH solutions				
1	1.0095	1.4	10.1	0.0842
2	1.0207	2.9	20.4	0.1704
3	1.0318	4.5	31.0	0.2583
4	1.0428	6.0	41.7	0.3481
5	1.0538	7.4	52.7	0.4397

(a) °Bé, Baumé; specific gravity for liquids heavier than water is $145/(145 - n)$, where n is reading on Bé scale in °Bé

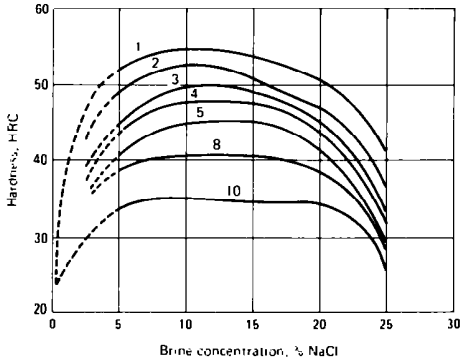
Operating Information

Brine concentration is expressed in several ways (see Table). Both sodium chloride and sodium hydroxide, the latter a caustic solution, are covered in the Table.

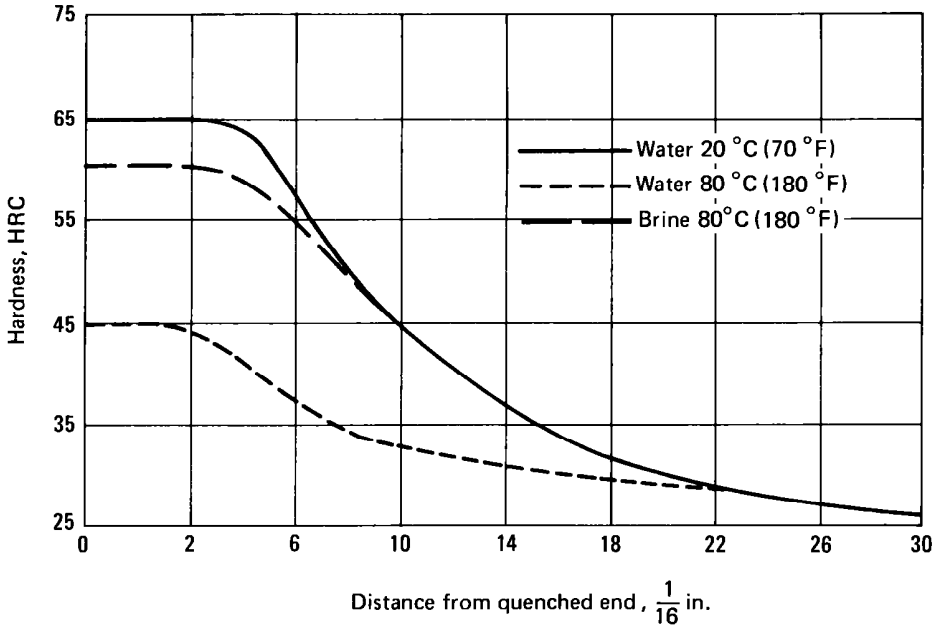
Brine concentrations up to 24 percent progressively reduce the vapor phase, but such concentrations generally are considered impractical. A 10 percent solution of NaCl is quite effective in hardening. The relationship of brine concentration to hardness is indicated in an adjoining Figure. It is necessary to monitor brine concentration to get reproducible results in quenching.

Cooling properties are not seriously affected by small variations in the operating temperatures. Brines can be used at temperatures near that of

Relation of hardness to brine concentration when still-quenching, end quench specimens 90 °C (195 °F) brine solution. Number above curves indicate distance from quenched end in units of 1/16 in. (Ref 2).



Relation of hardness to distance from quenched end of specimens quenched in water and brine. Cooling power of brine is greater than that of water at 80 °C (175 °F) (Ref 2).



boiling water, but their maximum cooling power is at a temperature of approximately 20 °C (70 °F). Effects of temperature on cooling power are indicated in an adjoining Figure.

Sludge and scale should be removed from baths periodically. They can clog pumps and recirculating systems and reduce cooling rates. Excess water reduces solution strength and cooling power.

References

1. Totten et al., *Handbook of Quenchants and Quenching Technology*, ASM International, 1993
2. *ASM Metals Handbook, Heat Treating*, Vol 4, 10th ed., ASM International, 1991

Caustic Quenching Process

The most common alternative to sodium chloride quenching is aqueous sodium hydroxide (a caustic) in concentrations ranging from 5 to 10 percent (Ref 1).

Characteristics

Cooling rates are similar to those of sodium chloride at high surface temperatures. Slower cooling rates than those available with sodium chloride are obtained in the martensitic transformation temperatures for many steels (<350 °C, or 660 °F), which would be expected to reduce susceptibility to cracking.

Operating Information

The effect of NaOH concentration on cooling rate, at a bath temperature of 20 °C (70 °F), is shown in an adjoining Figure. The effects of 1 to 5 percent concentrations of NaOH are shown in an adjoining Table. In practice, aqueous solutions are in the 5 to 10 percent range.

Comparatively, NaCl solutions are considered to be safer, less costly, and easier to handle than NaOH solutions. The main shortcoming of the latter is that its high alkalinity is harmful to human skin (Ref 2).

Relation of Brine Density to Brine Concentration of NaCl and NaOH Solutions

Salt, %	Specific gravity: Direct reading hydrometer	Specific gravity: °Bé(a)	Salt concentration: g/L	Salt concentration: lb/gal
NaCl solutions				
4	1.0268	3.8	41.1	0.343
6	1.0413	5.8	62.4	0.521
8	1.0559	7.7	84.5	0.705
9	1.0633	8.7	95.9	0.800
10	1.0707	9.6	107.1	0.894
12	1.0857	11.5	130.3	1.087
NaOH solutions				
1	1.0095	1.4	10.1	0.0842
2	1.0207	2.9	20.4	0.1704
3	1.0318	4.5	31.0	0.2583
4	1.0428	6.0	41.7	0.3481
5	1.0538	7.4	52.7	0.4397

(a) °Bé, Baumé; specific gravity for liquids heavier than water is 145/(145 – *n*), where *n* is reading on Bé scale in °Bé