SURFACE HARDENING

Engineering Materials and Metallurgy

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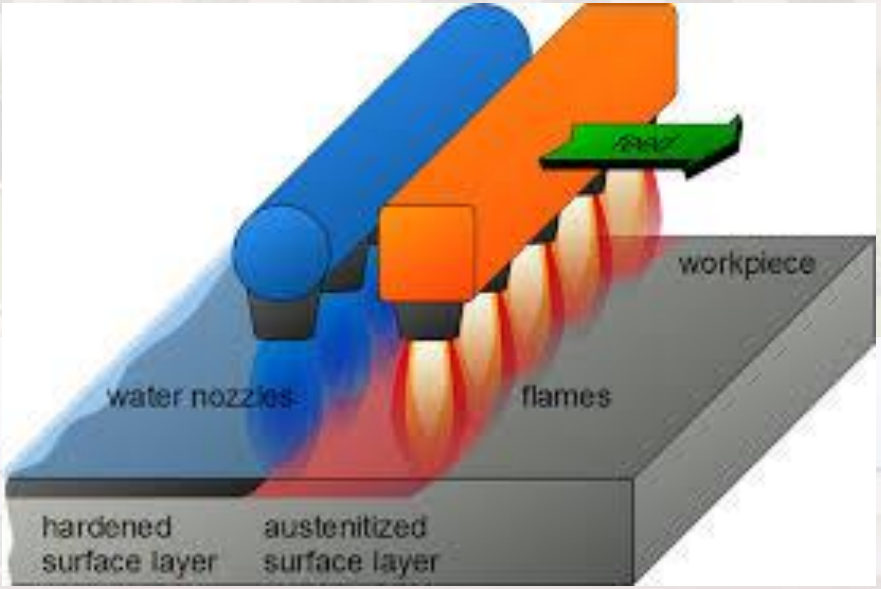
Surface Hardening

- Many engineering must be very hard to resist surface indentation or wear and yet posses adequate toughness to resist impact damage
- Surface Hardening is a process by which a steel is given a *hard, wear resistant surface,* while retaining a ductile but tougherinterior
- Surface hardening is usually done for the following reasons:

  - To improve wear resistance
  - To improve resistance to high contact stresses
  - To improve fracture toughness
  - To improve fatigue resistance, and, sometimes,
  - To improve corrosion resistance



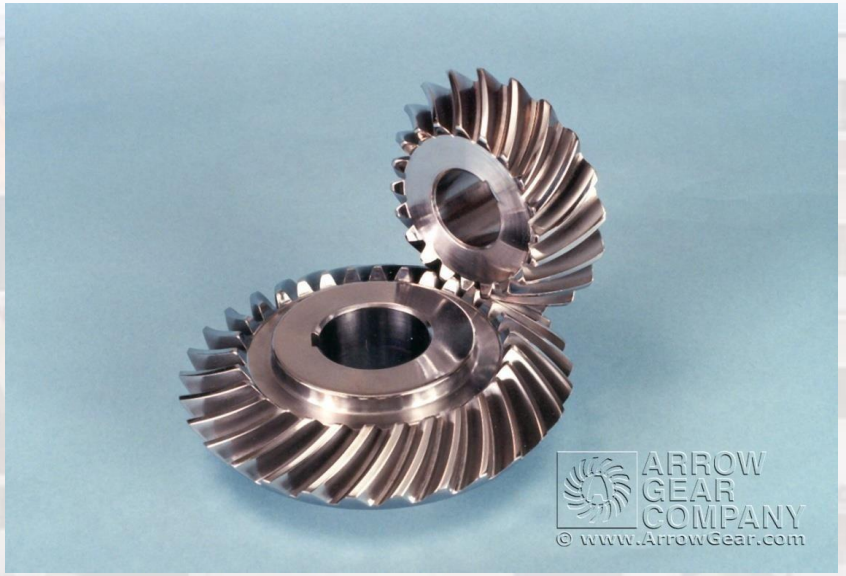
Source: Internet

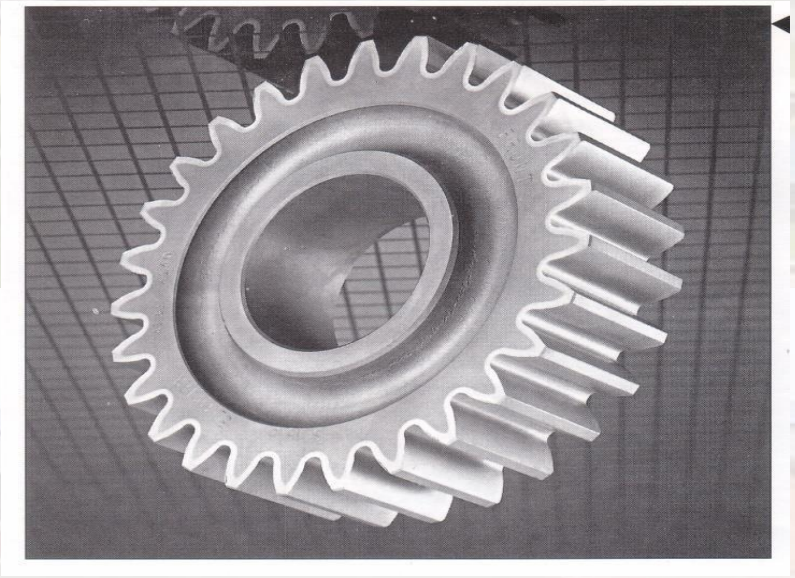
Heat Treatment examples

- gears	- bearings	- valves
- cams	- hand tools	- rolls
- shafts	- machine tools	- bearing races

- Surface hardening techniques can be classified into two major categories:

1. Processes that change the surface chemical composition (case hardening or thermochemical processes)
2. Processes that do not change the surface chemical composition (selective surface hardening or local thermal surface hardening)



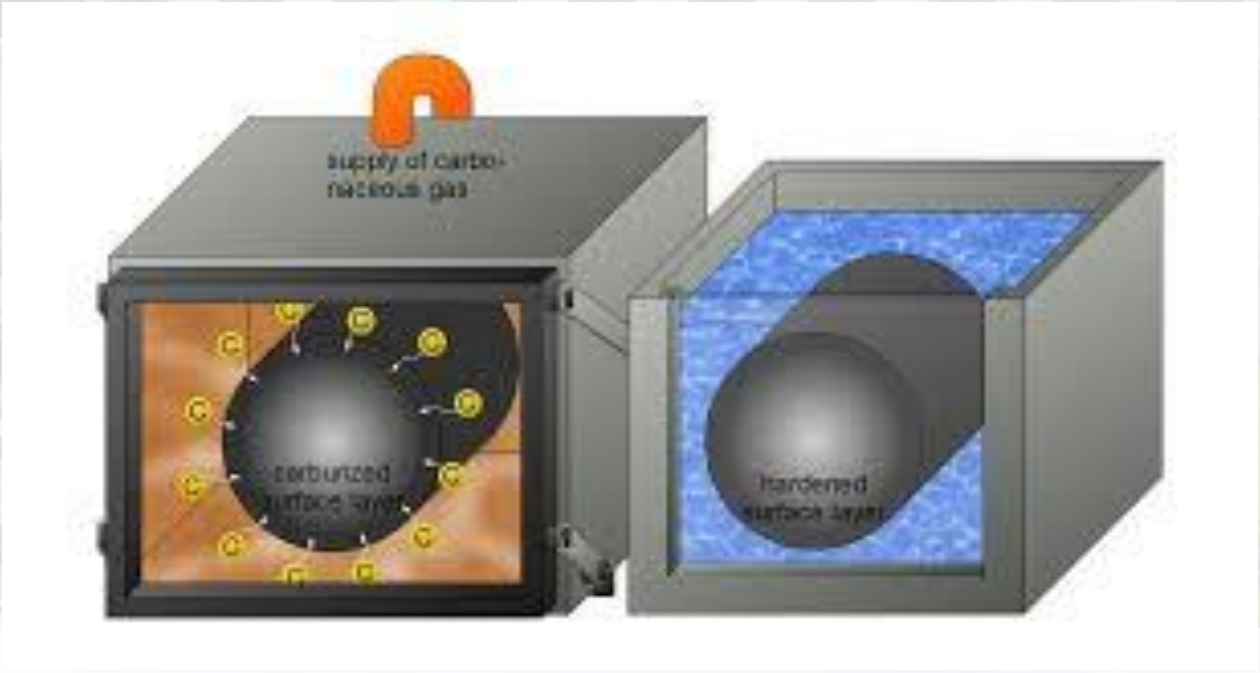


Source: Internet

Case Hardening

- Case hardening methods include:

1. **Carburising**
2. **Nitriding**
3. **Carbo-nitriding**
4. **Cyaniding**



Source: Internet

Carburising

- Carburising is a hardening process in which carbon is introduced into the surface layer of the steel

1. The steel is heated in contact with a substance that has a high carbon content
2. The steel is held at a temperature above the UCT (850 –950 ^{o}C) for a suitable period of time
3. Then quenched rapidly to produce a hardened surface layer or “case” over a softer and tougher core
4. The steel is then tempered to the desired hardness

Source: Internet

CARBURISING PROCESSES

GAS CARBURISING

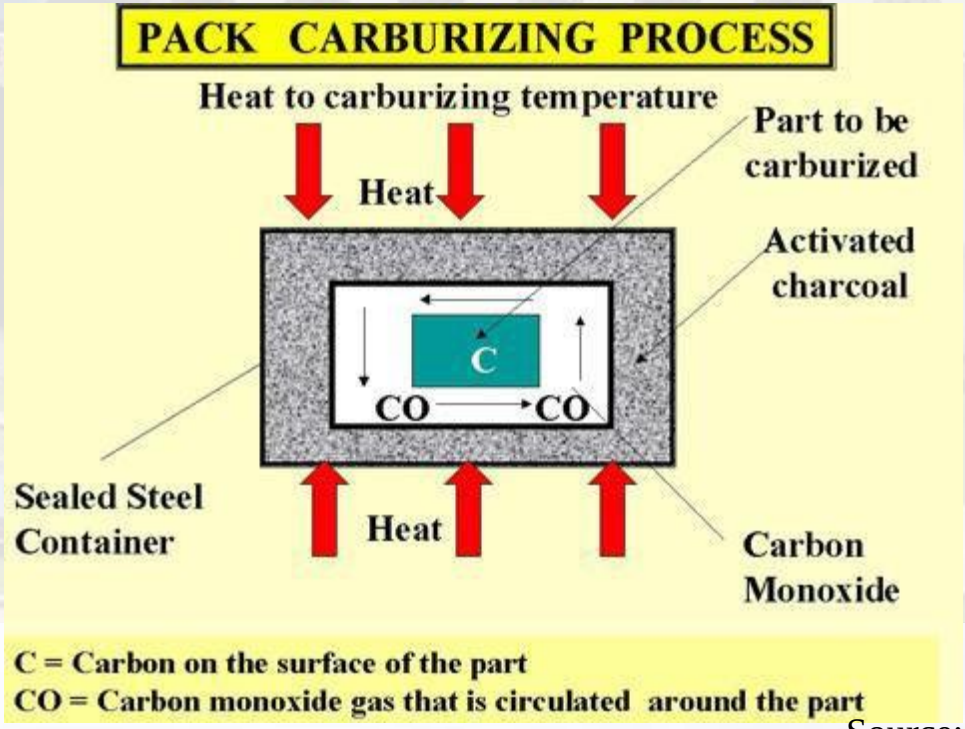
PACK CARBURISING

LIQUID CARBURISING

- Carburising is done on low C steel (< 0.25 %)
- The carburising time varies between 4 – 70 hours
- The length to time the steel is left in the furnace determines the *depth of carburising*
- Case depths ranging from 0.08 mm - 6.4 mm may be specified, depending on the service requirements of the product
- The carburising process does not harden the steel, it only increases the carbon content to a desired depth below the surface

Pack Carburising

- In pack carburising, the steel piece is packed in a steel container and completely surrounded with charcoal
  - The charcoal is treated with $BaCO_3$, which promotes the formation of CO_2.
  - CO reacts with the low carbon steel surface to form atomic C, which diffuses into the steel
  - Quenching is difficult in pack carburising. Usually the part is allowed to cool slowly and then hardened and tempered



Source: Internet

- **Carburising time: 4 – 10 hours**
- **carburising depth: no limit (< 1.3 mm)**

Gas Carburising

- Carburising is done with carbonaceous gases, such as: methane, ethane, natural gas or propane at around 930 ^{o}C
- The advantage of gas carburising is that the steel can be quenched directly from the carburising temperature

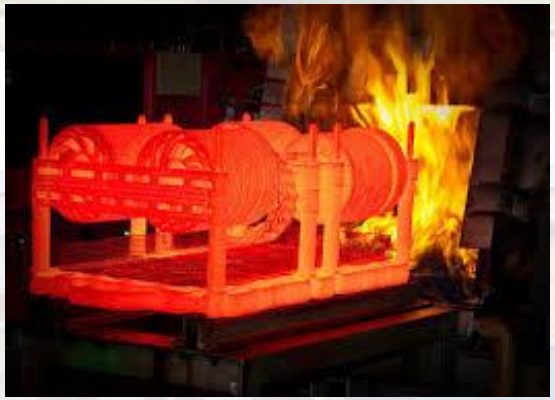
Liquid Carburising

- Carburising is done in liquid salts, which contain cyanide compounds such as NaCN
- Shorter carburising time compared to pack and gas carburising
- Environmental hazards of the salts used

Source: Internet

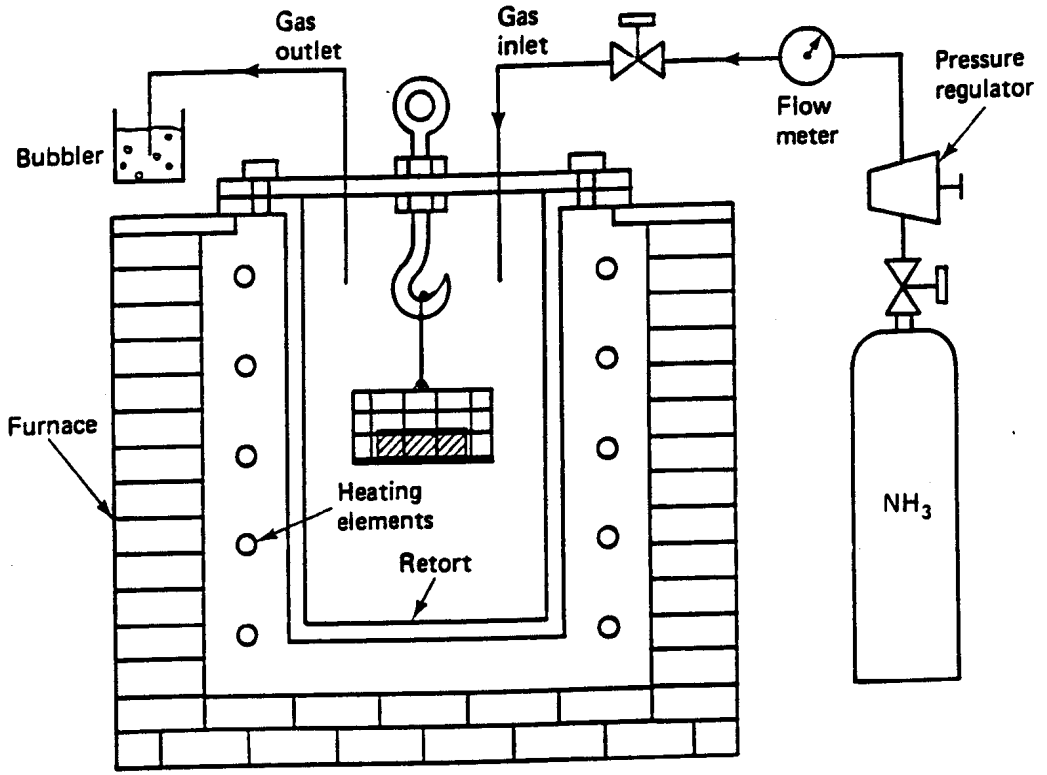
Nitriding

- In nitriding, the steel piece is heated in a furnace between 500 – 600 ^{o}C and at the same time is exposed to ammonia gas (NH_3)
- The heat from the furnace causes the ammonia to decompose into hydrogen (H_2) and nitrogen (N_2)
- Nitrogen reacts with elements in the steel to form nitrides in the outer layer of the steel providing high hardness and wear resistance
- Nitriding times range between 1–100 hours depending on steel composition and depth of hardening desired



Source: Internet

Nitriding



$2NH_3 \rightarrow 2N + 3H_2$

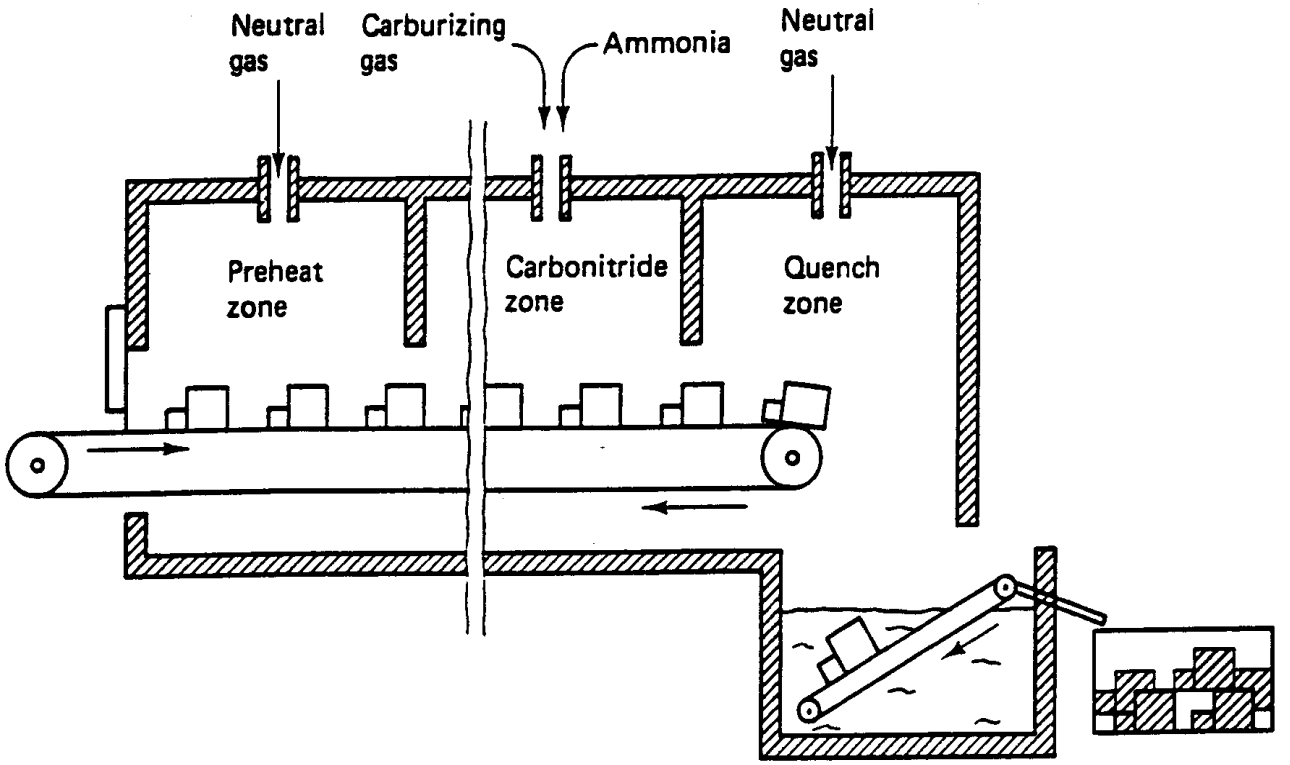
Source: Internet

Carbonitriding

- This process involves both the diffusion of C and N into the steel surface
- Nitriding is performed in a gas atmosphere furnace using a carburising gas such as propane or methane (source of C) mixed with several vol% of ammonia (NH_3) (source of N)
- Carbonitriding is performed at temperatures above the UCT (700 – 800 ^oC)
- Quenching is done in a gas which is not as severe as water quench (the result is less distortion on the material to be treated).

Source: Internet

Carbonitriding



Source: Internet

Cyaniding

- This process also involves both the diffusion of C and N into the surface layers of the steel

- In cyaniding, the steel is heated in a liquid bath of cyanide – carbonate – chloride salts and then quenched in brine, water or oil

Source: Internet

Selective Surface Hardening

- These processes are also called localised heat treatment because only the surface is austenitised and quenched to produce martensite
- The basic requirement for these processes is that the steel must have sufficient carbon and hardenability to achieve the required hardness at the surface (medium carbon steels are usually suited for these processes)
- Selective surface hardening are classified according to the heating source into:

1. *Flame hardening*
2. *Induction hardening*
3. *Laser hardening*
4. *Electron-beam heat-treating*

Source: Internet

Induction Hardening

- **Process:**
  - Induced current.
  - Metal will be surrounded in a quickly changing magnetic field.
  - Heating temperature: 750^{O}C – 850^{O}C
  - Quench in water.

Advantages

No scaling effect. Reduce distortion.
Consistent surface texture.

Disadvantages:

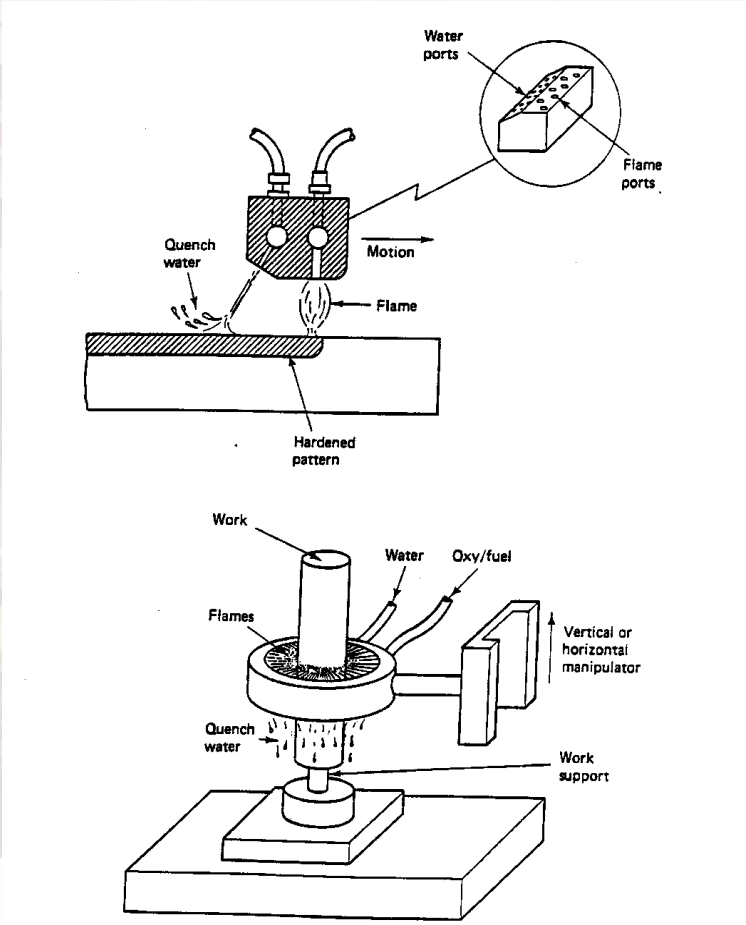
High cost

Applications

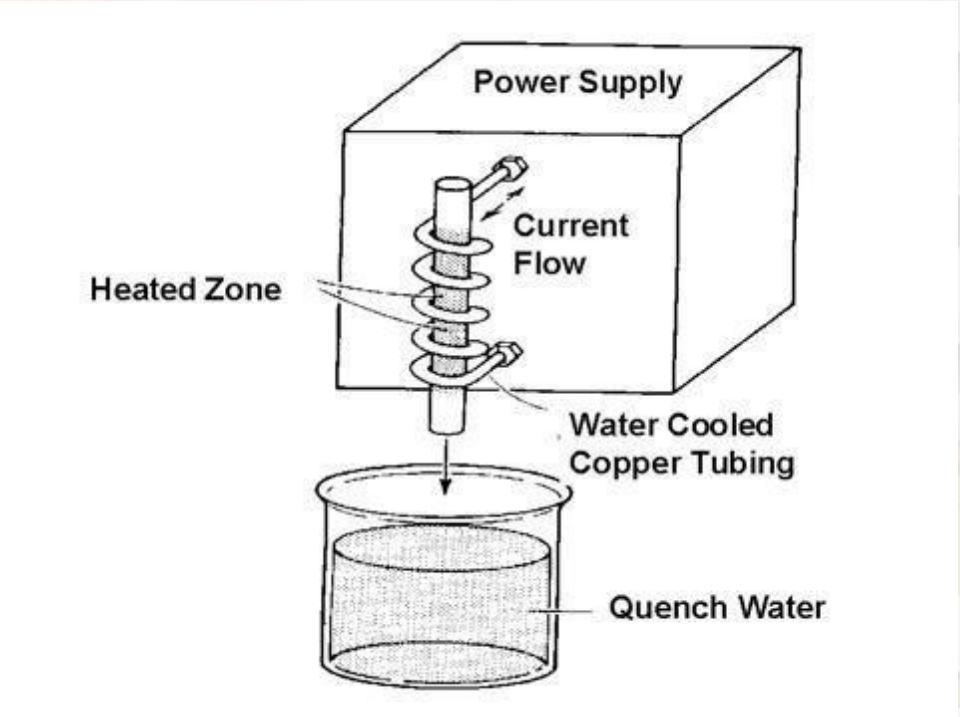
Crankshafts.

Gears.

Automotive components which require high core strength.



Flame Hardening



Source: Internet

Induction Hardening

Flame Hardening

Process:

Heated to γ region with 'oxyacetylene' flame.

Quenching.

Thin surface hardening.

Thickness control by temp. and time.

Advantages

- No scaling effect.
- Cheap and portable.

Disadvantages

'Overheating' can damage components.

Applications

Crankshafts.
Gears.
Automotive components which require high core strength.

	Heat treatment	Case hardening
%C	0.4-0.6	0.2
Austenized	surface	all
Speed of procedure	Fast (secs)	Slow (~10hrs)
Surface chemistry	No change	0.8-1.0%C (or N)
Depth	1-10mm	0.5-2mm
Surface hardness	R_c 57-60	R_c 65
Microstructure	martensite (may be through part)	surface martensite; centre pearlite
Control	difficult	easy
Residual stress	Surface compressive	Surface compressive
Core toughness	Medium (high C)	Good (low C)
Cost		Cheap $/part

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Source: Internet

THANK YOU

Assessment

https://play.kahoot.it/v2/?quizId=393600c8-49f3-43fc-a6ac-e0a53c0af529