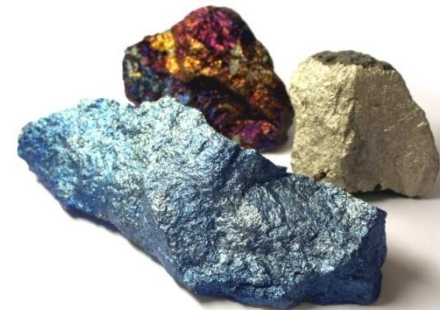




The Physics & Chemistry of Water in contact with Molten Metal

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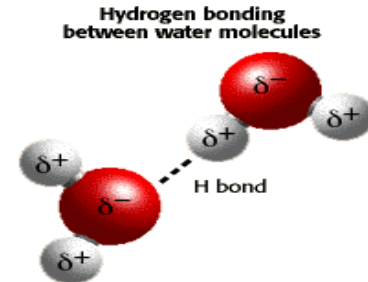




Topics

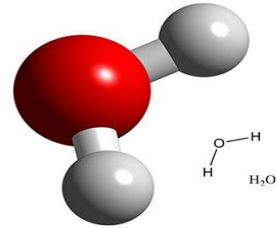
- Water
- Molten Metal
- Water's reaction in contact with Molten Metal
- Summary/conclusion

Characteristics of Water



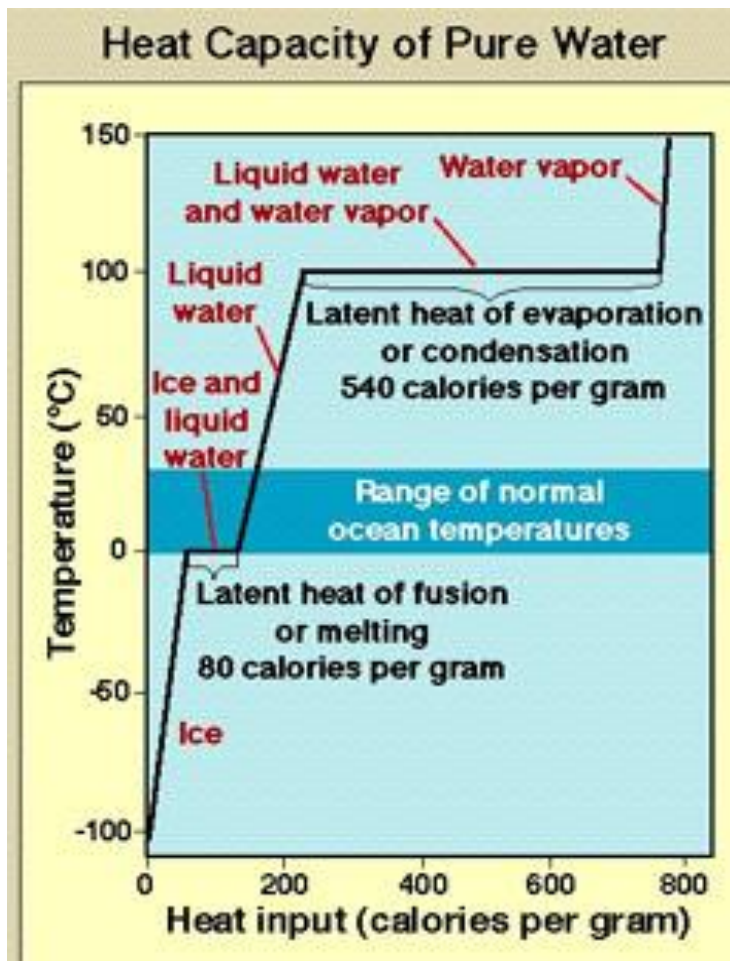
- Depending on the temperature water can exist in different states namely;
 - water is a liquid at ambient conditions
 - Water is a solid in the form of ice, frost etc at very low temperatures
 - Water is a gas in the form of water vapor or steam at 100 deg C

Water – The Chemistry



- Water is a chemical substance with a chemical formula – H₂O
- Its molecule contains one oxygen and two hydrogen
- The atoms connected by covalent bonds- a molecule
- The molecules are connected to each other by a Hydrogen bonds via bi-polar interaction

Water – The Physics



- As H₂O changes state, the amount of heat energy required to change its temp in the same state is referred to as the specific heat – expressed in calories.
- The specific heat of liquid water is 1.0 calories while it is 0.5 calories for ice.
- If we look at a graph of temp Vs heat input, we can follow the change from ice at -100C to water vapor at 150 deg C.
- In order to get the ice to the melting temp, it requires 100×0.5 or 50 calories.

Molten Metal



- Molten metal can simply be defined as metal in its liquid state
- At temp's of 300 to ca 2000°C, the solid metal or the alloy becomes liquid/fluid
- Fluid life depends on several other physico-chemical properties
- Engineers and occupational health scientists must understand these properties in order to reduce risk



Factors that affect the Liquid State of Metals

- Temperature
- Viscosity
- Surface tension
- Characteristics of the alloy or Metal
- Friction between molten material & mould
- Air pressure in the mould cavity
- Heat diffusivity of the mould
- Fluidity/fluid flow and solidification...

Molten Metal - Fluidity

- The capability of molten metal to fill mold cavities is called *fluidity*
- Fluidity is influenced by characteristics of molten metal such as:
 - *Viscosity, Surface tension, Solidification...*
- Fluidity is also influenced by casting parameters such as:
 - *Mold design, Rate of pouring, Mold material and its surface characteristics, heat transfer...*

Fluid Flow

Basic casting system:

Fluid is poured through a pouring basin

Flows through the gating system into the mold cavity

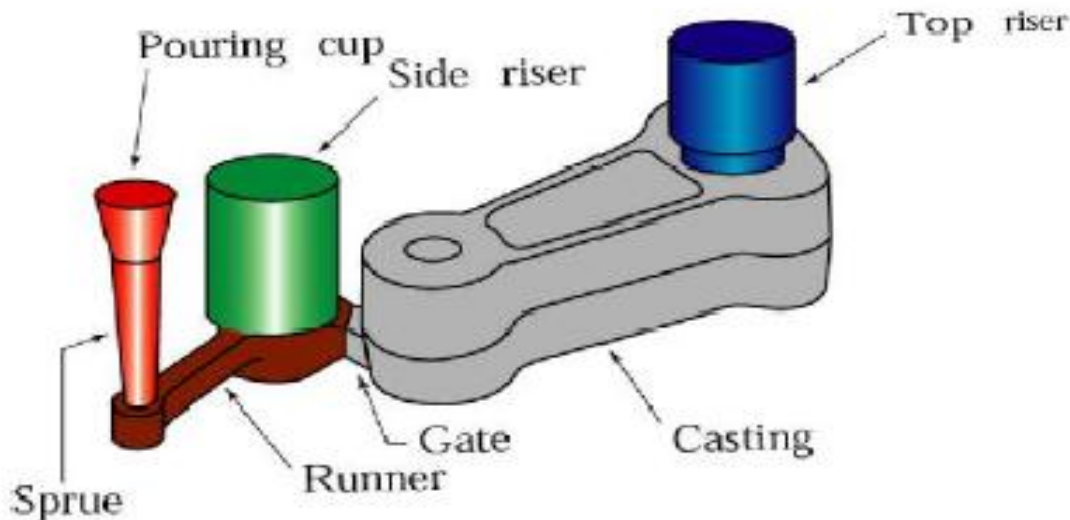
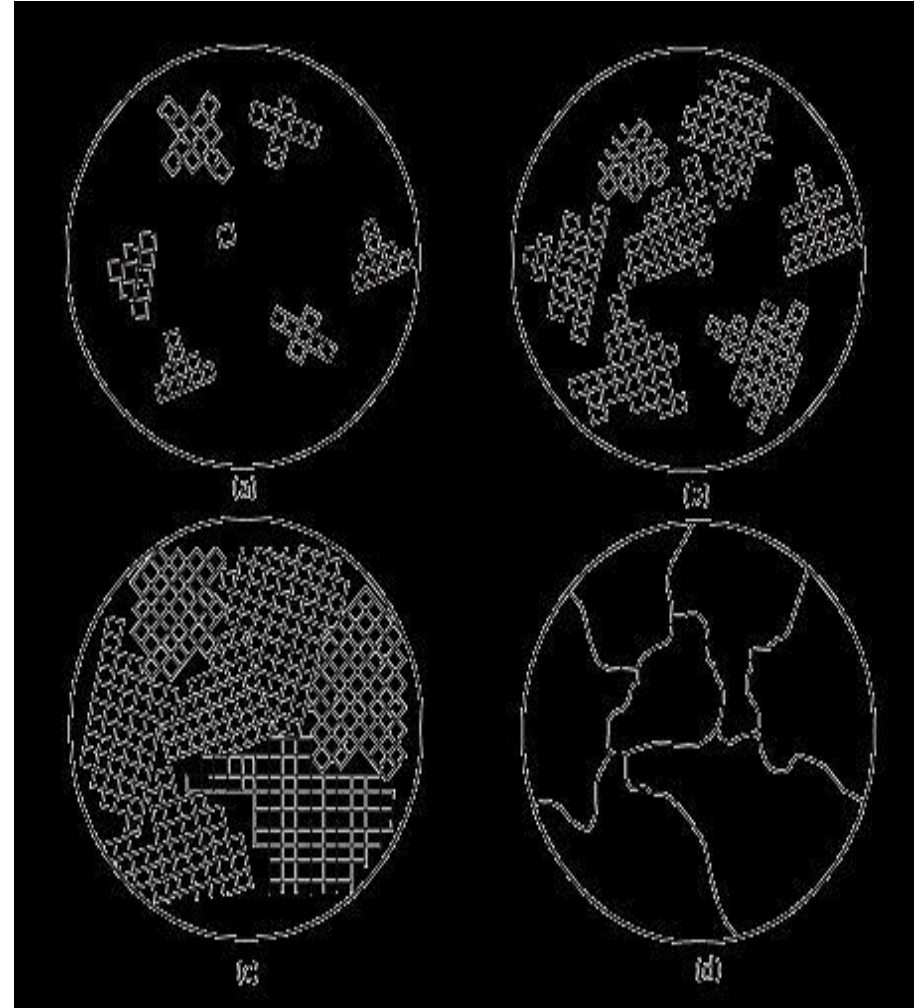


Fig : Schematic illustration of a typical riser-gated casting. Risers serve as reservoirs, supplying molten metal to the casting as it shrinks during solidification.

Solidification: The chemistry

- a) Atoms & molecules become disconnected
- b) Stable nuclei formation due to increased disconnection
- c) Formation of crystals of atoms = Small crystals
- d) Larger and stable crystals formation



What Engineers look for (1)

- As molten metal starts cooling, fluidity reduces as an oxide sheet forms on the metal surface
- Engineers consider three distinct stages of shrinkage as molten metal alloys solidify:
 - liquid shrinkage
 - liquid-to-solid shrinkage
 - solid shrinkage

Shrinkage stages – The detail

- Liquid Shrinkage: is the contraction of the liquid before solidification begins
- Liquid-to-Solid Shrinkage: is the shrinkage of the metal as it goes from the liquid's disconnected atoms & molecules to the formation of crystals of atoms & chemical compounds
- Solid Shrinkage: occurs after the metal has completely solidified and is cooling to ambient temp

Water in contact with Molten Metal



- Water changes from a liquid to a gas with extreme speed increasing dramatically in volume
- >1600 times its original volume causing an explosion
- A steam explosion sprays steam and boiling-hot water and the molten metal all directions
- Other potent metallic gases could be generated
- equally hazardous to health

Conclusions



- H₂O's ability to change state rapidly is temp dependent
- A change of state from liquid to gas results in an increase in the volume
- Large volume of gaseous H₂O (lighter) under Molten metal (heavier) is a recipe for explosion
- The lighter gas is under enormous pressure to find its way out – explosion
- A H₂O/molten metal explosion can occur in any type of furnace

Thank you!
Any Questions?

