

No- and Low-Water Power Plant Cooling

Brainstorming Results

More realistic is

Near Zero Water Power Plant Cooling

Questions:

how do you prevent ACC efficiency loss (from hotter Tcold)?

How do you design turbine to accommodate huge change in condenser steam specific volume (~10x)?

How do you incorporate thermal storage (latent, sensible) to achieve better than dry cooling efficiency?

How do you break up the boundary layer repeatedly (on the time scale of boundary layer reestablishment)?

Ideas:

Sonic nozzle – atomizes at 20 psi, makes fog sized water particles, really evaporate

Metal foam filled with paraffin – purchasable with 2 deg C melting point precision

Correctly designed foams can have 2-3x less pressure drop than undersigned foams

Rotating HX on bearing, HX is part of fan

Better fans might cut loss from fans by half (not total energy used by fans)

Ni plated steel can do coatings w Ni that are pinhole free, can now make HX from steel instead of aluminum and get same corrosion resistance

All Diamond Heat Exchanger - What about push for national effort to make industrial diamond cheap

stretched polyethylene got 100 W / m / K (Chen, MIT) don't have process to scale it structure is like diamond in 1D of 3, but made from plastic

spider silk 400 W / m / K (Iowa, published in Advanced Material)

HXs with smaller and more tubes, less fin

vibrating plastic flexible fins (piezoelectric, acoustic, etc.)

could steer sound waves using phased array of microphones

can you break boundary layer with a mechanical wiper

perforated fin

Why aren't we dumping heat to space? Via really large surface areas at night

Follow up with DARPA Thermal Management Technologies (TMT), especially Microtechnologies for Air-Cooled Exchangers (MACE)

Proposed Metrics

Primary

DeltaT steam to air, average

10 K

(they have done 30 K in past but with steel cheap they can go lower like 20 K)

Heat transfer coefficient for fixed fan power and area

$h = 150 \text{ W/m}^2 / \text{K}$

(50 possible today, using total exposed surface area of fins)

Parasitic loss (fans, pumps, other)

cooling power / heat power produced by power plant

or

cooling power / electric power produced by power plant

(today 1.5% of steam portion of plant output power is fan power needed for ACC)

Cooling Water Consumption

0.1% of water in cooling loop

(Well maintained wet cooled plant makeup water is 1% of water in cooling loop,

10% of this 1% would be a worthy goal for cooling water use)

Thermal storage is allowed

Secondary

Cost

\$0.02 / W of dumped heat

or LCOE = 5c/kWh

(this is today's typical wet cooling costs)

Fan Noise

<85 dB

this is plant standard now OSHA, 60 dB at property line

Redundant

(dh/h0)/(dp/p0)

Proposed Deliverable:

5-50 kW cooling system, perhaps including storage

must do day to night thermal cycling

1000 hours of continuous running by end of 3 year project