How the Thorium Reactor and Modified Gas Turbine Work

First, print this article out so you can refer to it while looking at a steam plant drawing. It's probably best to look at the drawing on the opening page - the one about a gas turbine power plant. Click on the drawing a couple of times to enlarge it enough so that you can read the small lettering.

The THORIUM REACTOR. The reactor is basically a tank filled with graphite (what we call “pencil lead”). The graphite is cut to fill the tank tightly leaving a space at both the top and bottom. Dozens of tubes spaced about 2 inches apart - arranged in a grid - are drilled the length of the graphite between the top and bottom spaces to allow the molten fuel salt to flow through the graphite from bottom to top.

Somewhat like slowing a passing meteorite to assure that Earth’s gravity will draw the meteorite to crash into it, the graphite slows neutrons – moderates their speed - thereby increasing the chances the neutrons will crash into nearby uranium atoms and cause the atom to break apart - or fission – releasing a bit of heat in the process.

There are no tubes drilled near the edges of the graphite. This thick graphite edge keeps neutrons in, acting as the first of three radiation containment shields in the reactor barge concept. The other two containment shields are the 3 foot thick concrete and steel walls of the reactor’s 70 feet in diameter, 50 foot high containment cell (colored blue) and the three foot thick concrete walls of the concrete reactor barge (colored gray).

The molten fuel salt has dissolved radioactive fuel (usually uranium-235) in it which is radiating neutrons that fission (split) adjacent atoms which, in turn, produce the reactor’s heat as the salt travels up through the reactor tank from bottom to top via the tubes drilled in the black graphite block in the reactor tank.

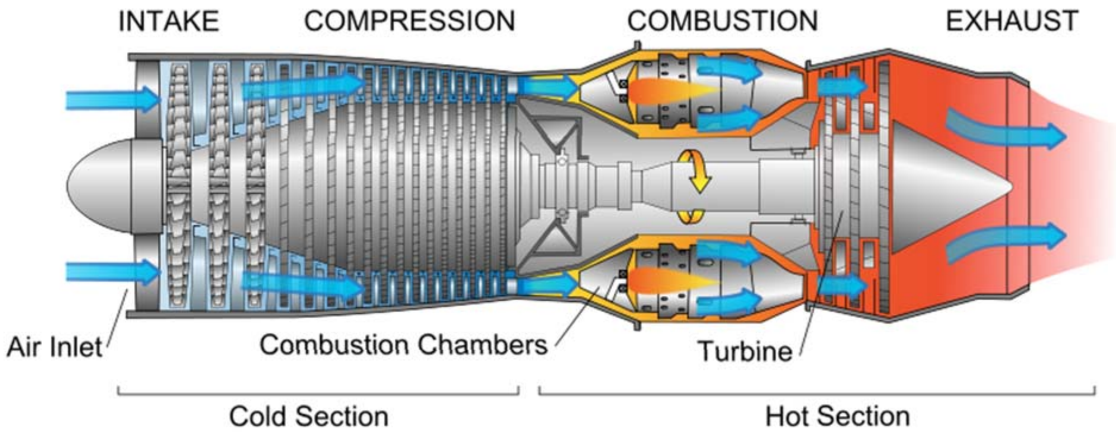
Once the reactor is up and running on something radioactive, non-radioactive thorium can be blended into the liquid fuel. Thorium, when exposed to radioactivity, changes over about a month into radioactive uranium-233 and becomes the reactor’s fuel. The reactor can be kept running for about 30 years on thorium before the fuel salt becomes so contaminated with fissioned uranium-233 it will stop running.

After 30 years of full-power running, the salt is cleaned by precipitation and the graphite rods, swollen by 30 years of exposure to intense radiation are replaced with fresh graphite rods.

Pumps next to the top of the reactor tank then pump the heated fuel salt down through the 4 primary heat exchangers inside the reactor cell which then heat the non-radioactive "clear salt" loop.

Notice the molten salt travels through the heat exchangers so fast the salt's temperatures don't change much more than 100F.

The MODIFIED GAS TURBINE or “Jet Engine.”



A gas turbine works by drawing air in with an intake turbine, (cold section) compressing it, then heating it (hot section) in combustion chambers to increase the air’s pressure even more, then exhausting the hot, higher-energy air, through an exhaust turbine.

The air is heated by burning jet fuel, natural gas, or some other combustible fluid in the jet engine’s *combustor*.

Roughly speaking, the increase in energy, minus the energy lost in driving the turbines, is the amount of energy that was converted from heat to mechanical energy. This energy can be used for making electricity by attaching a generator to the cold end of the rotating turbine shaft.

To repower a jet engine with a nuclear reactor, the combustion chambers are replaced with heat exchangers heated by the nuclear reactor’s clear salt loop. The jet engine will extract about 600°F of mechanical energy from the 1,300°F heat exchanger, discharging air at 700°F. This 700°F blast of heat is used to heat the “Heat Recovery Steam Generator.” This is why this system is called “Combined Cycle.”

A jet engine repowered with a 1,300°F nuclear heat exchanger will not produce as much shaft power as it would by burning a 2,100°F fossil fuel.

Since no burning takes place, this turbine does not make Global Warming carbon dioxide.

The “COMBINED CYCLE” STEAM GENERATOR.

The clear salt (salt loop 2) is also used to heat a “Duct Heater” which adds more heat to the jet engine’s 700°F exhaust before the exhaust enters the “Heat Recovery Steam Generator,” a new boiler that was added to replace the original coal-burning Loeffler boiler that was originally used to produce the 3 three different steams needed to power the original steam turbine electricity generator.

The following steam pressures and temperatures are generic values right out of the "Steam Plant Operation" handbook by Woodruff, Lammers, and Lammers.

Water expands 1,600 times in volume when it changes from water to steam. If not allowed to expand, its vapor pressure will rise dramatically. Steam has proven to be a wonderful way to turn thermal energy into mechanical energy for 300 years.

The heat recovery steam generator does 4 things.

1. It preheats the condensate water (blue water line) to 500F so that thermal shock will not crack or overload the evaporator. This temperature also sets the lowest [saturated] steam pressure available.

2. The evaporator temperature sets the operating (saturated) steam pressure. When running at 670F the evaporator sets the steam pressure to 2,500 psig.

3. The steam then rises through the superheater section where the steam is superheated from 670F to 1,000F (red steam line). (Superheating means the steam is hotter than is necessary for its pressure. This makes steam more powerful and also “dry”, like a gas.) The steam then passes through the high pressure stage of the turbine where it expands, dropping the pressure to 550 psig and the temperature to 500F (pink steam line). (If running at part power, the HP turbine can be by-passed.) This temperature/pressure combination takes the steam dangerously close to becoming wet fog (477F @ 550 psig), which will rapidly destroy by erosion the blades and buckets of the intermediate stage (IP) turbine.

4. To make the steam safe for use in the intermediate turbine, the steam is reheated from 500F to 1,000F to dry it out and then the steam is run through the intermediate pressure turbine. The pressure remains at 550 psig.

The steam then leaves the intermediate pressure turbine stage and immediately goes to the low pressure or "condensing" stage turbine at 710F and 170 psig and then on into the steam condenser (hot well) which is running at a slight vacuum to keep the steam from forming fog. At this point the steam flashes back into water – reducing its volume 1,600 times and thus maintaining the vacuum – and the water is then run through a de-aerator and then into a storage tank for the next trip around. That’s it!

Since no burning takes place, this boiler does not make Global Warming carbon dioxide.

COMMENTS:

Since conventional reactors run about 550F, they are not able to produce the more efficient 1,000F steam temperatures coal produces. Molten salt reactors, however, were running at 1,300F right from the beginning.

The reactor containment cell can be buried in an underground silo for additional radiation shielding if the barge is not an option. Air cooled, this reactor cell won’t make any additional demands for cooling water.

Making the reactor barge a stand-apart module with molten salt feed and return lines to a reactor is not to be found in the literature. This enables quick disconnect from the steam generator module for quick barge replacement. Using the secondary heat exchanger as a load-consolidating heat distribution device (see Big Bend and Jorf Lasfar) is also undocumented as far as I know but the idea of having one boiler drive many different heat zones (such as in steam heating) is as old as the hills.

The inerting gas cascade is set up to detect and handle fine leaks between salt stages, forcing any leakage toward the reactor and its confinement cell.