THE CONSULTANT

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Chairman's Corner — *John Dunn, President, Ambertec, Inc.*

Mercury vapor street lamps used to give off, I think, a rather good simulation of daylight as they enabled people to see clearly into otherwise dark places, but mercury vapor street lamps have now been replaced with sodium vapor street lamps because, we are told, the sodium vapor lamps use up less electricity.

As with LED traffic lights, we see the search for energy efficiency.

Unfortunately, the yellow color of the sodium vapor lamps has been found to cause diurnal (day-night) cycle disruptions of street trees which then start to sicken.

Also, the yellowish light doesn't seem to penetrate the darkness as well as the mercury vapor's white light did, so, to solve that problem, new and blindingly bright sodium vapor lights have been installed in my neighborhood, which takes us back again to using more electricity while continuing to damage the trees.

We now see in the news that some states are looking into banning the sale of incandescent lamps in favor of those spiral shaped fluorescent lamps, again for the sake of energy efficiency. After all, those new lamps not only use less energy, they last a lot longer too.

Still, they eventually wear out and while they're not recyclable, they do have to be disposed of and, oh, by the way: They contain mercury.

Am I not understanding something here?

Meetings

April 2007

Topic: Business meeting: Preparation of a New Printed Directory.

There were many ideas and suggestions. We decided that we would continue the discussion at a future meeting with Dave Allen of Mainly Marketing Enterprises, Inc. contributing his ideas.

May 2007

7:00 PM, Wednesday, May 2, the first Wednesday of the month.
Briarcliffe College, 1055 Stewart Avenue, Bethpage, NY
See website for directions: www.consult-li.com

Topic: Business meeting. Continuation of Preparation of a New Printed Directory, with input from Dave Allen.

Topic: Rail Voltage Ripple Estimation
Speaker: Mr. John Dunn, Ambertec, Inc., Merrick, NY

Light refreshments will be served? Admission is free (no charge), and no pre-registration is required. For more information, contact Chairman John Dunn at (516)378-2149 or e-mail ambertec@ieee.org.

Other Meetings

Consult the Events Calendars on the Section website: www.ieee.li and the LICN site: www.consult-li.com.

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Mother of All Feedback Loops — *Richard LaRosa, sealevelcontrol.com*

This is about a deep-sea-moored pumping station that is powered by the temperature difference between the warm surface water and the cold deep water. The cold water, which is pumped up from 1000-meter depth, cools the surface and supplies nitrates, phosphates, and iron to the phytoplankton which float in the upper, sunlit layer of the ocean. These nutrients enable the chlorophyll in the phytoplankton to convert the dissolved CO2 into increased phytoplankton mass, which is eaten by zooplankton, and so on up the ocean food chain.

The pumps and other on-board components are powered by an alternator which is driven by a turbine. Warm surface water is pumped through an evaporator heat exchanger to vaporize ammonia. The ammonia vapor expands through the turbine and exits to a condenser heat exchanger. Cold water from 1000-meter depth is pumped through this heat exchanger to make the vapor condense. The liquid ammonia is pumped into the evaporator, which operates at a higher ammonia pressure than the condenser.

The pumping station consumes no fuel when it is running in steady state. However it must be started with electric power supplied to its pump motors and control circuits from a service vessel. Before start-up the entire quantity of ammonia is in a vapor state and its temperature is equal to the ocean surface temperature. The system is initially only partially charged with ammonia in order to limit the pressure. As the pumped-up deep water cools and condenses some of the ammonia, more ammonia is added from the service vessel until the turbine is up to speed and the ammonia pressures are at their design value. The electric power is supplied from the service vessel's inverter or frequency converter so that it can be synchronized with the voltage of the turbine-driven alternator of the pumping station. During start-up, the load must be gradually shifted from the service vessel to the pumping station's alternator in order to keep the speed of the turbine and the frequency of the alternator output at the design value.

I have never seen this starting sequence described in the OTEC (ocean thermal energy conversion) literature. Perhaps it was archived about thirty years ago in the National Technical Information Service (NTIS) or some other repository, when government-funded OTEC development programs were being shut down. It will take some effort to find this information, if it exists. There are no OTEC systems in operation because all programs other than this present effort were burdened with the requirement to export significant power. This program recognizes the value of the pumped-up cold water and nutrients, and allows all power to be used to just run the system. This results in a thermal cycle efficiency increase that will (I hope) insure success.

During start-up, and also when the system is running without help from the service vessel, there is the possibility of unstable operation. To see this, suppose that the turbine is directly coupled to a four-pole alternator which is supposed to run at 1800 rpm to generate 60 Hz power. This was actually proposed during an optimization study for a 10 MWe net power OTEC system (a system intended to supply 10 MW of electric power to a load that is external to the OTEC plant). Provision for turbine speed regulation was planned for that system, but for the purpose of this illustration, let us suppose that the speed is controlled solely by the loading of the warm-water, cold-water, and ammonia pumps. If the turbine speed should decrease for some reason, the output frequency of the alternator will decrease. Therefore the synchronous speed and the actual speed of the induction motors driving the pumps will decrease. The water and ammonia pumping rates will decrease. This will decrease the output power of the turbine, which will result in a further decrease in turbine speed.

Thus we see that the system might shut itself down. Perhaps we need a feedback loop that specifically controls the turbine speed. In the 10 MWe study referred to above, variable first-stage nozzles were incorporated in the turbine. These are the stationary vanes that direct the incoming vapor toward the first set of rotating blades. They act like a throttle to control the turbine speed. The measured turbine speed is compared to a reference value to determine the nozzle setting. Other feedbacks may be required to stabilize the system against changes in various environmental parameters, such as surface water temperature, or deterioration such as water contamination of the ammonia or biofouling.

A successful system design requires an analysis of its power output, range of control, and robustness. System variables such as surface water temperature, turbine inlet pressure, turbine outlet pressure, flow rates at various locations in the ammonia flow path, water flow rates, alternator output voltage and current, etc. must be assigned time-varying values as independent variables or left as time-varying dependent quantities to be determined by analysis. In the worst case, there will be non-linearities that make it impossible to break these up into a superposition of independent single-frequency terms. Looking back through my career, I don't recall solving problems like this, although I remember something about right-hand poles. Oscillators are supposed to have a complex conjugate pair of these in order for a waveform to grow until some mechanism limits it. We have to write all the relations between the variables and then eliminate all but one of the dependent variables. Lots of luck! Two years ago, I was under the impression that OTEC was an almost-developed technology. Now, I wonder where I got that idea.