Process and Power Dictate the Design of Refinery

Expansion at Whiting, Indiana is marked by: comprehensive water treatment for high-makeup operation, extensive reducing-desuperheating facilities for ironing out inequalities of power and process loads, overload protection for topping units*

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▶ WHEN AN INDUSTRIAL PLANT requires steam for both power and process, these demands rarely parallel each other for any appreciable period. At Whiting, the following steps were taken to satisfy this condition: (1) high initial pressure (2) steam-conditioning equipment for reducing steam from initial boiler pressure and temperature down to turbine-exhaust conditions. In addition design precautions guard against accidental overloading of generators, and deposit of scale on boiler and turbine surfaces from feedwater chemicals.

Selection of a high enough initial operating pressure permits generating the peak electrical-energy demand even during periods of the lowest process-steam needs. Beyond this base requirement, a surplus over present demands should be built into the topping cycle to *meet future load growth.*

Our experience dating back to 1928 indicates the soundness of building-in a surplus over and above present needs. At that time one of the earliest industrial applications of byproduct generation of power was made at Whiting with a power station operating at 400-psi and 650-F initial steam conditions. Exhaust from turbine-generators was delivered to the refinery for process and power at 100 psi and approximately 450 F. The quantity of steam required by the refinery produced considerably more byproduct power than was needed at that time.

Refinery operations change, however. Over the years it became the practice to replace uneconomical steam drives with motor drives utilizing inexpensive byproduct electric energy. Process design changes over this same period further reduced refinery steam demands per barrel of crude oil.

In fact, the tendency has been for steam demand to stay static or possibly increase at a slight rate. Electric energy demand, on the other hand, has increased at a high rate. Our former surplus soon disappeared. It became apparent that total byproduct power available at the then existing back-pressure cycle would fall far short of ultimate power demands. All this background figured heavily in our selection of initial steam conditions for our new plant.

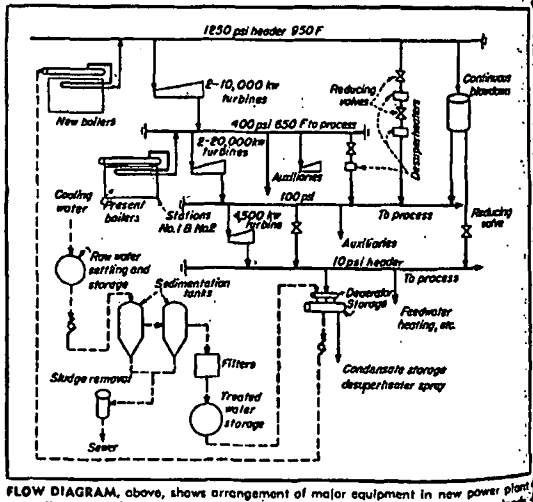
Steam Conditioning. Providing steam-conditioning equipment, to reduce steam from the initial pressure and temperature conditions of the topping cycle down to turbine-exhaust level, takes care of inequalities in demands for steam and power.

For normal operation two pressure-reducing and desuperheating stations perform this conditioning function. A 75,000-lb-per-hr station operates first, followed up by a second, a 300,000-lb-per-hr unit that cuts in automatically when the smaller one reaches its limit.

Two additional stations of 300,000 lb per hr can reduce this high initial steam from the 1250-psi 900-F topping cycle level down to 400-psi 650-F exhaust conditions. One of these serves as a standby; the second safeguards steam supply to refinery process (see "Overload Precautions," p 103) if a topping turbine trips out.

Each pressure-reducing and desuperheating station consists of (1) a diaphragm-operated pressure-reducing valve of the pilot type (2) a steam-jet water-spray nozzle desuperheater.

* Part 1 of this 2-part article appeared in March Power, pp 84-88.



FLOW DIAGRAM, above, shows arrangement of major equipment in new power plant as well as its relation to existing steam-generating capacity and process loads. Heart of the expansion program is the new dual-circulation boilers, upper left. They supply 1250-psi steam under 100% makeup conditions with little blowdown

Condensate for spray water comes from condensing vapor from the deaerating heater in oversized vent condensers. The condensing medium is relatively cold raw water on its way to the feedwater-treating plant. A compartment of the deaerator storage tank holds the condensate from this process after it has been deaerated in a separate section of the deaerator.

If condensate supply exceeds demand it overflows into adjacent compartments of the storage tank where deaerated boiler feedwater is kept. A 30,000-gal tank at the deaerator-storage level acts as an emergency storage point.

Now for the pressure-reducing valves themselves. Reduction of pressure, in valves of the type usually employed in this service, gives off an objectionable noise, especially if they are close to the operating stations. Today's valves plus their piping lower this noise level appreciably. But there is still a noise nuisance.

Because there are so many pressure-reducing stations at the Whiting Refinery any measures toward isolating this noise became desirable. All stations —1250 psi to 400, 400 to 100, and 100 to 10 psi—occupy a separate room above the roof of the turbine room, isolated from the boiler room by a solid brick wall. An acoustic material deadens sound to contribute to the comfort of those who work in this space.

Feedwater Treatment. With steam at four pressure levels, 1250, 400, 100 and 10 psi and makeup approaching 100% for the 1250-psi boilers, water treatment is an important phase of plant operation.

The treatment system is set next to the power station and is laid out to permit ultimate expansion to that of the steam-generating capacity. At present it consists of three lime-soda sedimentation tanks—one serves as a spare—and two phosphate sedimentation tanks. Each pair of tanks comprising a unit has a net capacity of 80,000 gal per hr. Retention time runs 1½ hr.

A 4700-sq-ft storage room adjacent to a railroad siding houses water-treatment chemicals in bags and barrels. Chemical mixing and proportioning takes place in a room next to this storage space. Mixing tanks stand slightly above grade elevation.

Arrangement of these tanks permits dumping chemical charges from a platform that connects with the storage room at its floor level. Separate tanks mix lime and soda, phosphate and retardant solutions. Each tank carries its own agitator, proportioning mechanism, suction pump tank and chemical pump. Controls for all chemical proportioning and feeding mechanisms and pumps mount on a central control board. The same board holds all flow and level recorders, pressure gages and other instruments needed to control the entire water-treating system.

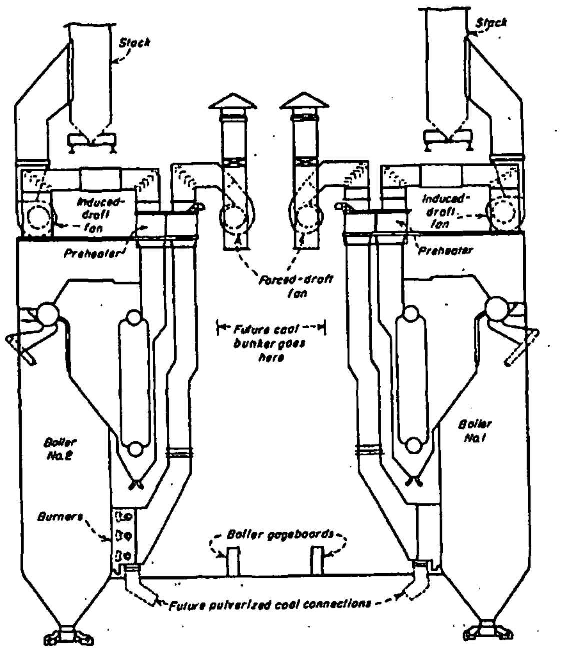
Each sedimentation tank can recirculate sludge from the sludge cone to the top of the tank. This accelerates precipitation. An ejector, a flowmeter and a clear-water pump make up the recirculating equipment. The ejector and flowmeter are placed close to the tank to reduce length of sludge pipes; the clear-water pumps are in the mixing room.

Raw-Water Cycle. Raw water presettles in two storage tanks, 50 x 50 ft. Its incoming temperature varies with the season and with process changes over a range of about 120 to 180 F.

Water to the new power plant, Station No. 3, flows through two 18-in. pipes to raw-water pumps in the pump bay of the boiler room. It passes from here through vent condensers on the deaerating heaters to spray heaters on the sedimentation tanks. At maximum capacity, water at 180 F entering the vent condensers leaves at 238 F. In the sedimentation tanks this temperature rises to 240 F, corresponding to a 10-psi exhaust-steam pressure.

Under emergency conditions with raw water at 40 F entering the deaerator vent condensers, outlet temperature reaches 162 F. Full capacity of the treating tanks can be maintained with raw-water inlet temperature as low as 90 F.

Steam for heating in treating tanks comes from refinery exhaust-steam mains and from continuous-blowdown flash drums. Because many steam-driven reciprocating engines operate throughout the refinery, exhaust from these mains is kept out of the deaerators. Uncontaminated steam for deaera-



FIRING AISLE ARRANGEMENT of new dual-circulation boilers. Each has its own separate stack, no economizer, and uses a regenerative form of air preheater