PLANT NEWS

11POWER PLANTS OF SMALL HYDRO (1,960～10,376kW) METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA, USA

The Metropolitan Water District delivers a total of 1,400,000 acre-feet of water per year, of which 900,000 acre-feet is delivered through a gravity flow distribution system from the terminal reservoirs of the Colorado River and the California aqueducts.

It is necessary to provide pressure reducing stations at many locations within the distribution system, because of the large changes in elevation. As is true of many other water distribution systems, these stations rely on throttling valves to reduce the pressure and regulate the flow. Hydraulic energy is unavoidably wasted in the process.

The Metropolitan Water District has studied these pressure reducing stations and decided to adopt energy saving power generating systems, considering the increasing costs of electricity necessary to run their large pumps.

Fuji supplied the turbine and generator equipments and technical advice to general contractors who built the plants.

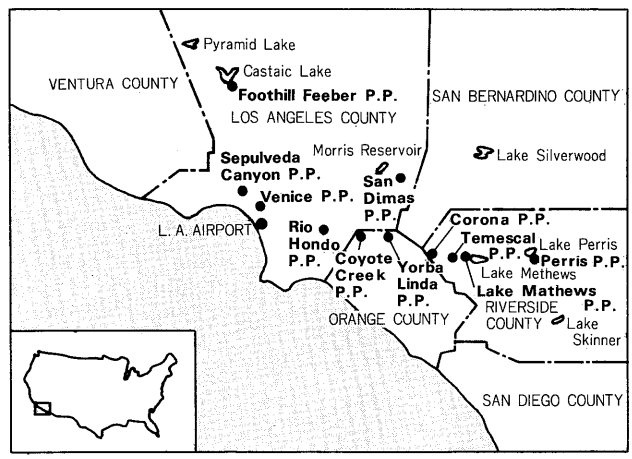

Fig. 1 Turbines and generators supplied by Fuji Electric

Table 1 Ratings of turbines and generators

Plant	Unit	Turbine					Generator		
		Output [kW]	Head [m]	Discharge [m³/s]	Speed [rpm]	Type	Output	Voltage [kV]	Type
Lake Mathews	1	5070	32.30	17.70	327.3	VF VF	4900 kW	4.16	IG
Foothill Feeder	2	4670	62.80	8.50	600	VF	4516 kW	4.16	IG
San Dimas*	1	10149	136.20	8.50	200	VP	9924 kVA	4.16	SG
Yorba Linda*	1	5117	61.36	9.60	120	VP	5089 kVA	4.16	SG
Sepulveda Canyon*	1	8808	111.56	13.45	120	VP	8540 kVA	4.16	SG
Venice*	1	10376	111.25	13.45	600	VF	10120 kVA	4.16	SG
Temescal	1	2948	44.20	8.50	600	HF	2850 kW	4.16	IG
Corona	1	2948	44.20	8.50	600	HF	2850 kW	4.16	IG
Perris*	1	8160	54.25	16.99	514	VF	7940 kVA	4.16	SG
Rio Hondo	1	1960	71.02	3.12	1200	HF	1910 kW	4.16	IG
Coyote Creek	1	3230	72.54	4.96	900	HF	3125 kW	4.16	IG

Note: * : Outdoor type hydro generating power station
VF : Vertical Francis turbine
VP : Vertical Pelton turbine
HF : Horizontal Francis turbine
IG : Induction generator
SG : Synchronous generator

FEATURE OF POWER PLANTS

The Metropolitan Water District hydroelectric power plants have the following features which are applicable for future energy saving hydraulic power plants.

1. If the generator is disconnected from the electrical system while power is being generated (an inevitable event), the rotational speed of the turbine generator will increase until it reaches runaway speed, which is about 180 to 200 percent of the rated speed.

Runaway is not a significant problem to the turbine or generator since they are designed to withstand this condition. The flow through an impulse turbine is unaffected by the speed of the runner; however, the flow through a reaction or propeller turbine may be seriously affected by the runner speed.

This flow change on runaway could produce dangerous water hammer stresses in the pipeline similar to those caused by the instantaneous closure of a valve. Since most water distribution systems are not designed for instantaneous valve closures, water hammer was a critical problem.

Low specific speed reaction turbines cause a major reduction in flow, which could create water hammer conditions upstream of the turbines. Similarly, high specific speed reaction turbines and all propeller turbines would cause a massive flow increase which would create water hammer conditions,downstream of the turbines.

Devices, such as surge tanks and bypass valves, could be incorporated in the design to limit any water hammer damages; however, these devices are either too expensive, or involve on unacceptable risk of failure.

Taking these facts into consideration, Metropolitan has elected to limit selection to impulse turbines, and to reaction turbines with specific speeds of constant flow characteristics.

2. The distribution pipelines are already installed, therefore, the pipelines cannot withstand pressure rise at time of load rejection as they are. The closing time of the wicket gate or the needle is lengthened to approx. 15-30 minutes so that the pressure variation can be minimized (The length of the penstrocks are 800 m-28km.)

3. In case the closing time of the wicket gate is lengthened an enormous flywheel effect (WR^2) is required to keep suitable speed-variation at load rejections, which is not economical.

Therefore, the WR^2 value is natural inertia and the max speed variation is the runaway speed which the generator can withstand Approx. 30 minutes.

4. The generating plants, which require long-time closing of the wicket gates or the needle, cannot operate under isolated load, therefore, induction generators are adopted, taking into consideration economical saving. (Maximum capacity: 4900 kW, beyond which synchronous generator should be adopted.)

5. It is difficult to keep linear characteristic of the closing time for these wicket gate and needle servomotor using the hydraulic oil pressure system, in case long closing time is required. Therefore, geared motor operating systems are adopted, and conventional governor and pressure oil supply systems are deleted. As a result, turbine auxiliary units can be simplified.

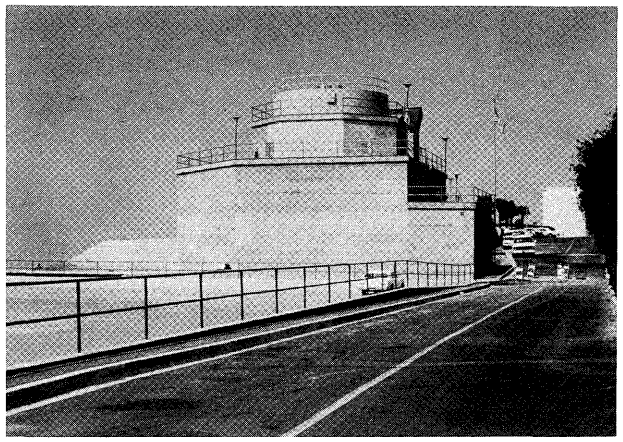

Fig. 2 Yorba Linda power plant (outdoor type power station)

Note) Photo by courtesy of Metropolitan Water District

6. The deflector of the impulse turbine is operated by an oil pressure system, for which bladder type accumulator (rubber bag named bladder is used and N2 gas is sealed in one side.) is adopted in place of conventional pressure oil tank, and the air compressor is deleted in order to simplify the auxiliary unit.

7. As to the construction of the vertical turbine-generator (2 power plants), the mono-block construction, which has been adopted already in Japan (The lower guide bearing of generator is deleted, and the whole turbine and generator set is supported by two guide bearings) is adopted for purpose of economy. Thrust bearings are located at the upper bracket of the generator, and the brake is installed at the turbine guide bearing support.

8. As to horizontal machines, the runner of the turbine is overhung construction, and two bearings are installed at each side of generator (the turbine bearing is deleted.)

Taking disassembly into consideration, the thrust bearing is located at the opposite side of the turbine, and the runner and the wicket gates, etc., can be disassembled from draft tube side.

9. Five (5) power plants of 11 power plants are the outdoor type hydro generating power station, which has no powerhouse and no lifting device.

10. The turbine=generator machine construciton and its performance for the Corona Power Plant is the same as the one for the Temescal Power Plant. Both the Temescal and Corona Power Plants are located on teh same pipeline providing head sustaining structures with bypass, and effective head between the upper reservoir and lower reservoir at this pipeline is accurately divided into two sections. Each effective head is applied to these turbines which are operated in series.