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(19)

(54) POWER STATIONS

(71) We, NUCLEAR POWER COMPANY LIMITED, a British Company, of 1 Stanhope Gate, London W1A 1EH, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:-

This invention relates to a method of operating power stations which are used both for generating electricity and for providing a supply of heat to process plant, and to a suitable combination of a power station and process plant.

It is normal practice to operate the turbine-generator of a power station at less than its maximum continuous output so that in the event of a sudden increase in the demand for electricity the power output of the turbine generator can be increased immediately. The spare capacity of a turbine-generator operated in this way is known as "spinning reserve" and is typically up to 20% of the generator capacity.

In addition to spinning reserve operation, power stations are frequently required to operate at reduced load to match the actual supply of electricity to variations in demand. When the power station is designed as a dual purpose plant to produce both electricity from the turbo-generator and process heat to be untilised in associated process plant provided for the purpose, the steam supply system is normally designed to be capable of producing sufficient heat to run both the turbo-generator and the process plant at maximum continuous output. The steam supply system is therefore operating below its maximum capacity for most of the time; and where the capital cost of the steam supply system is high in comparison with the costs of fuel and the rest of the plant (for example in a nuclear power station) this results in an inefficient use of the high-cost plant.

It is an object of the present invention to provide a method of operating a dual-purpose power station in such a way that the steam supply system is operated at a high load factor. The available steam which is not required for electricity generation is employed to provide process heat, and the essential feature which distinguishes this method of operation from that conventionally used is that the process plant capacity is determined with a view to making the most economic use of the steam supply system and not to match the passout capacity of the turbine of the turbogenerator. The product of the process plant should therefore be capable of being stored.

According to the invention, in one of its aspects, there is provided a method of operating a dual-purpose power station comprising a nuclear-powered steam source, turbogenerating means connected to be driven by the steam source, and steam-powered process plant susceptible of wide variation of its rate of operation, wherein the turbogenerating means has a maximum continuous supply rate of the steam source and the method comprises operating the turbogenerating means normally with substantial spinning reserve and simultaneously therewith operating the nuclear-powered steam source substantially at its maximum continuous supply rate and feeding to the process plant the excess steam thereby produced and, in response to increased electrical demand, increasing the steam supply to the turbogenerating means while correspondingly reducing the steam feed to the process plant.

Preferably, the process plant having a maximum steam consumption rate substantially greater than the difference between the maximum steam consumption rate of the turbogenerating means and its consumption rate when operated with normal spinning reserve, reduction of the electrical output of the turbogenerator means in response to

reduction of demand below that satisfied by operation thereof with normal spinning reserve is effected by reducing the steam consumption rate of the turbogenerating means while correspondingly increasing the steam feed to the process plant and maintaining operation of the steam source substantially unchanged at its maximum continuous supply rate.

Preferably, when the turbogenerator means comprises high-pressure and low-pressure steam-turbine stages connected in series, steam for the process plant is fed thereto after being passed through the high-pressure turbine stage and variations in steam consumption of the turbogenerator means are effected by varying the proportions of the steam fed respectively to the process plant and to the low-pressure stage of the turbogenerator means from the high-pressure stage thereof.

According to the invention in another of its aspects there is provided a dual-purpose power station comprising a nuclear-powered steam source, turbogenerating means connected to be driven by the steam source and having a maximum steam consumption rate substantially matched to the maximum continuous supply rate of the steam source, steam-powered process plant connected to be fed with steam from the steam source and susceptible of wide variation in its rate of operation, and means for varying the feed of steam to the process plant while operation of the steam source is maintained substantially unchanged at its maximum continuous supply rate.

Preferably, the turbogenerator means comprises high-pressure and low-pressure steam turbine stages, the high-pressure stage having an inlet connected to the steam source and an outlet connected by respective throttle valves to an inlet of the low-pressure stage and to the process plant. Preferably also, in such a case, the inlet of the high-pressure stage is connected to the steam source through another throttle valve, and a further throttle valve connects the steam source to the process plant, by-passing the high-pressure turbine stage.

By way of illustration a dual-purpose power station, and the method of operating it, according to the invention will be described with reference to the accompanying drawing, which is a diagrammatic representation of the power station.

The illustrated installation comprises a high-cost steam source 1, specifically, in the illustrated case, a steam generator 2 supplied with heat from a nuclear reactor 3; and the steam source 1 is combined with turbogenerator means 4 and with a process plant 5 which may, for example, be constituted by a set of sea water distillation units for the production of fresh water.

When maximum electrical output is required, the nuclear reactor 3 is run at its maximum output and all or almost all the steam produced by the steam generator 2 is passed through a high-pressure turbine 6 and thence through a fully-open throttle valve 7 to a low-pressure turbine 8 of the turbogenerator 4, and finally into a condenser 9 from which condensed water is recirculated to the steam generator 2. The high- and low-pressure turbines 6 and 8 drive an alternator 10 of the turbo-generator 4. The supply of seam to the distillation plant 5 is either cut off completely or reduced to the minimum required for stable continuous operation of the distillation plant 5. If the steam supply to the distillation plant 5 is not completely cut off, it would be taken from the outlet from the high pressure turbine 6, through a throttle valve 11.

The normal operating condition would be with the alternator 10 operating at a load which would allow spinning reserve capacity (the alternator then operating typically at 80%-90% of full load). The turbine power is matched to the load on the alternator, by passing out steam from the outlet of the high-pressure turbine 6 through the valve 7 to the low-pressure turbine 8. The steam passed out through the valve 11 is used to operate the distillation plant 5 at a load commensurate with the heat available.

When the alternator 10 is required to operate at low load, the steam flow to the inlet of the high pressure turbine 6 is reduced by means of another throttle valve, 12, and the steam flow from the steam source 1 (still operating at unreduced rate) is maintained by diverting steam through a further throttle valve 13 direct to the distillation plant 5.

In order for this system to be flexible in operation it is essential that the distillation plant should be able to accept random fluctuations in the available steam supply over a wide range of conditions. For this reason it is preferred to employ distillation plant of a type which will respond automatically to variations in heat input. The Vertical Tube Evaporator system for distillation is an example of a suitable type of plant.

From the foregoing description of an example, it will be seen that the invention provides a method of operating a power station to provide both electricity and heat for other processes, wherein the steam source or supply system is operated continuously at or near its maximum continuous rating and the heat supply which is not required for generating electricity is used to operate a process plant.

The invention thus provides a means of raising the utilisation of a high-cost capital plant of the steam supply system of a power station by providing relatively low-cost pro-

cess plant to absorb the surplus heat (variable with time) from the steam supply system.

WHAT WE CLAIM IS:-

1. A method of operating a dual-purpose power station comprising a nuclear-powered steam source, turbogenerating means connected to be driven by the steam source, and steam-powered process plant susceptible of wide variation of its rate of operation, wherein the turbogenerating means has a maximum steam consumption rate substantially matched to the maximum continuous supply rate of the steam source and the method comprises operating the turbogenerating means normally with substantial spinning reserve and simultaneously therewith operating the nuclear-powered steam source substantially at its maximum continuous supply rate and feeding to the process plant the excess steam thereby produced and, in response to increased electrical demand, increasing the steam supply to the turbogenerating means while correspondingly reducing the steam feed to the process plant.

2. A method as claimed in claim 1, wherein, the process plant having a maximum steam consumption rate substantially greater than the difference between the maximum steam consumption rate of the turbogenerating means and its consumption rate when operated with normal spinning reserve, reduction of the electrical output of the turbogenerator means in response to reduction of demand below that satisfied by operation thereof with normal spinning reserve is effected by reducing the steam consumption rate of the turbogenerating means while correspondingly increasing the steam feed to the process plant and maintaining operation of the steam source substantially unchanged at its maximum continuous supply rate.

3. A method as claimed in claim 1 or claim 2 wherein, the turbogenerator means comprising high-pressure and low-pressure steam-turbine stages connected in series, steam for the process plant is fed thereto after being through the high-pressure turbine stage and variations in steam consumption of the turbogenerator means are effected by varying the proportions of the steam fed respectively to the process plant and to the low-pressure stage of the turbogenerator means from the high-pressure stage thereof.

4. A method as claimed in any of claims 1 to 3 and substantially as described herein.

5. A dual-purpose power station comprising a nuclear-powered steam source, turbogenerating means connected to be driven by the steam source and having a maximum steam consumption rate substantially matched to the maximum continuous supply rate of the steam source, steam-powered process plant connected to be fed with steam from the steam source and susceptible of wide variation in its rate of operation, and means for varying the electrical output of the turbogenerator means by varying the feed of steam to the process plant while operation of the steam source is maintained substantially unchanged at its maximum continuous supply rate.

6. A dual-purpose power station as claimed in claim 5, wherein the turbogenerator means comprises high-pressure and low-pressure steam turbine stages, the high-pressure stage having an inlet connected to the steam source and an outlet connected by respective throttle valves to an inletof the low-pressure stage and to the process plant.

7. A dual-purpose power station as claimed in claim 6, wherein the inlet of the high-pressure stage is connected to the steam source through another throttle valve, and a further throttle valve connects the steam source to the process plant, by-passing the high-pressure turbine stage.

8. A dual-purpose power station as claimed in any of claims 5 to 8, wherein the process plant is a salt-water distillation plant.

9. A dual-purpose power station substantially as described herein with reference to, and as shown in, the accompanying drawing.

For the Applicants
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1 SHEET This drawing is a reproduction of the Original on a reduced scale