PEAK OPERATION OF HEATING POWER STATIONS

PROBLEMS ARISING ON THE CONSUMERS' SIDE, I

By

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The methods of the operation of power stations for peak power have been elaborated by the Study Department of the Institute for Power Economy [6—8].

Preface

With fast technical development and changes in the structure of energy carriers, new modern concepts have emerged with respect to the building and operating of heat-supplying power stations and the district supply of heat. These new concepts, in turn, suggested the idea to use heating power stations for the generation of peak energy. We speak about this problem from the consumers' aspects, viz. with space heating tap water supply and the heat lost in the pipe system.

The first part deals with the reasons which justify peak operation, its methods, potentialities, its economic advantages, and measurements performed.

The second part gives an assessement of the features of peak operation from the consumers'side, pointing to the dimensioning, calculation, and modelling methods to be used with this novel type of operation.

1. Why operate heating power stations for peak power?

The population of towns and larger communities takes the facilities available in the 100-year old drinking water supply, in the approximately 80 year old electric power supply, as well as the city and — more recently — natural gas services, for granted. In some countries of Europe, Asia and America, under their given geographical and meteorological conditions, the supply of heat as a public utility occupies the same important position as that of drinking water and gas. The realisation of this situation suggested the idea of the district supply of heat, taking into consideration also the many well-known advantages it offers to the consumer.

While the immense advantages inherent in district heating have come into focus, particularly since the Second World War, with housing developments mushrooming everywhere in the world, it is of as great an interest also in industrial and agricultural settlements, hospitals, office blocks and educational institutes, etc.

District heating, as a modern, aesthetic, hygienic and comfortable system to satisfy the consumers' demand for heat was, already at the beginning of the fast spread of district heating, linked up with the maximum consideration of the energetics aspects.

Demand for heat for heating and hot tap water supply at relatively low temperature can be advantageously met by making available the enthalpy of the expanded medium, after it had performed work in the turbine. This method of heat supply enhanced the difference between the cycle used in the condensing power stations of the period at and after the introduction of district heating (20 to 30 years ago), and the backpressure cycle (which is best suited for the district supply of heat) concerning their specific heat consumption figures: As against the 4000—3000 kcal/kWh specific heat consumption of the condensing cycle, the backpressure cycle needs only around 1200 kcal/kWh. Apparently, the consumers of water for heating and hot tap water, having functioned as "useful condensers" had a favourable effect on the specific heat consumption figures.

There was another fact which could not be disregarded from the economic point of view: the capital investment of a heat supplying power plant was lower than the first costs of a condensing power plant of the same capacity (a "complementing" power station) and a boiler plant representing the same heat supplying capacity.

Over and above their dissimilar specific heat consumption and specific first costs, the efficiency of the thermal power plant and the heating boiler plant differs widely, especially if they are fuelled with coal of a lower calorific value. Since the efficiency of the power plant boiler was up to 80 per cent and that of the boiler plant not higher than 65 to 70 per cent, the gap between the specific heat consumption was further widened by the gains derived from the difference between the boiler efficiencies.

Further savings could be achieved in heat supplying power plants in labour, since the wages of the personnel in the condensing power station plus the heating boiler plant, in most cases, far exceed the labour costs in a heating power station alone.

This is then an explanation for the popularity of heat supplying power plants. Two more points should, however, be considered:

a) that heat supplying power plants, too, have their shortcomings;

b) that the transformation of the structure of energy carriers combined with technical advance, has changed the above outlined four points which had a share in the fast spread of heating power stations.

ad a) In heat supplying power stations — provided that they are of the backpressure type — the electric power produced depends on the amount of heat supplied to the consumers. The utilisation factor is one of the most important indices of economical operation of a heat supplying power station.

ad b) The changes in the structure of energy carriers, and technical development, have compensated for the difference between heat supplying and condensing power stations, and introduced a good number of factors in favour of boiler plants.

In the first place, technical progress enabled a considerable reduction of the specific heat consumption of condensing power stations.

In the second place, the use of hydrocarbons, oil and natural gas has caused a drop in coal consumption. An increasing supply of oil gave stimulus for the production of inexpensive low-capacity oil-fuelled boilers for use in minor industrial plants, central or district heating systems, which are sold ready for use and which lend themselves for automation [1, 2].

The above outlined phenomena and developments have changed and modified the concept of heat supplying plants, and raised the following two major problems:

a) Under what conditions is the building of new heat supplying power stations a paying proposition?

b) In what system should heat supplying power stations be operated to be competitive again?

ad a) When new heating power stations are established, it is reasonable to design them for the simultaneous supply of industrial and heating energy. If, namely, industrial and heating demand arise concurrently in a consumer's area, their satisfaction from the same power station increases the utilisation factor and substantially reduces the costs charging the heating, as compared with the case when heating demand must be covered by a separate heating power plant [3—5].

ad b) However now, discussing the new method of operating heat supplying power stations, we have come to the gist of this chapter: to clarify what the operation of heat supplying power stations in the peak periods exactly means, and why their running is justified.

Under the peak operation of heat producing power stations, such management when the power plant makes use of the thermal storage capacity of the heated objects, and transmission pipelines, yields the possible maximum power during the peak electric consumption periods.

This in turn means that during the peak period, the quantity of heat yielded by the power plant per hour, depending on the station's type, is higher or lower than the demand. Naturally, the daily total heat yield must, even in peak operation, correspond to the heat demand pertaining to the daily mean temperature. Accordingly, in addition to meeting the demand of the heat consumers the heat supplying power stations are capable of utilising the maximum installed capacity during the maximum periods of consumption.

Peak operation is, therefore, justified because: in existing power stations it improves the economy of operation and brings a certain amount of saving in first costs. With the introduction of peak operation, central (remote) heat supply will again be able to compete with modern or fashionable heating systems, individual heating, and heat supply from block boilerhouses.

2. Methods of peak operation

The running of heat supplying power stations, with peak operation, is determined by the following three factors:

- the type of the heating turbine installed at the heating power plant;
- whether remote heat supply is of a heating power station or a combination power plant which supplies both industrial and heating heat;
- whether the remote heat supply extends to heating only, or to heating and hot water supply, together.

The turbine installed in the heating power stations may be of the
extraction backpressure, or
extraction condensing, type.

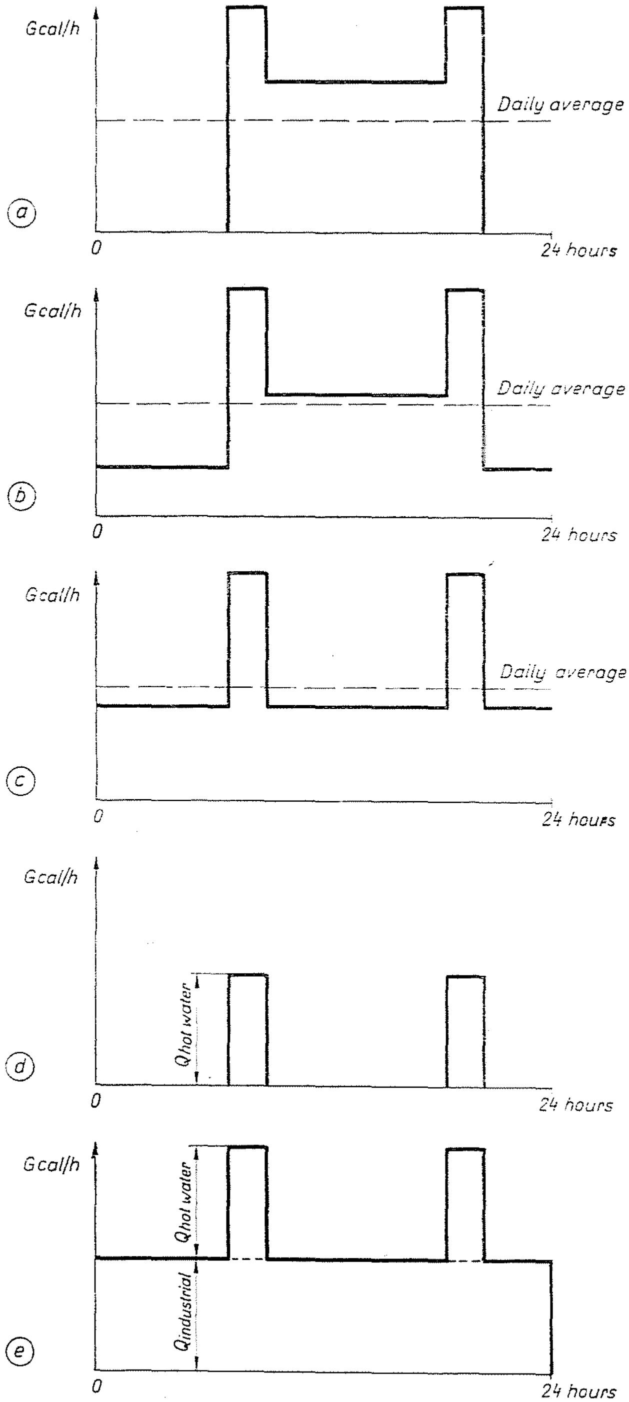
a) *Peak operation with extraction backpressure turbines*

Peak operation in the winter season. In the Hungarian backpressure heating power plants, mostly the so-called "Hungarian" heating turbines are used, a type in which backpressure and the pressure of bleeding changes in the function of the load. If the remote supply of heat takes place from a heating turbine, peak operation means that the heating turbine, regardless of ambient temperature, during the peak periods of electric load (2-2 hours in the morning and towards the evening), runs at maximum capacity. This type of operation is called "positive" peak operation (Fig. 1).

The quantity of heat produced in addition to the momentary demand, is stored in the remote heating network and in the heated objects themselves. The schedule of the supply of the balance of the daily heat quantity depends on whether the power plant in question satisfies heating plus industrial heat demand, and whether the remote supply of the population includes the supply of hot tap water too, or not.

Operation according to 1/a means that the daily heat supply outside the peak period is, in its entirety, fed into the remote heating network during the daytime.

If, for the safety of hot tap water supply, it is not feasible to produce the total quantity of daily heat during the day, then operation 1/b may be resorted to.


Gcal/h
Daily average
a
0
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b
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24 hours
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Daily average
c
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Gcal/h
Q hot water
d
0
24 hours
Gcal/h
Q hot water
Q industrial
e
0
24 hours

Fig. 1

Should the temperature of the forward flowing hot water surpass the permissible maximum during the evening peak, the balance of the daily quantity of heat would have to be supplied at a uniform rate outside of the peak period (see 1/c), or the heating turbines would have to be run at a minimum load before the evening peak.

Peak operation in summer. The method of the peak operation of heating power stations in summer depends on the demand for hot tap water. From this fact it follows that summer peak operation in the heating power plant may be considered only if the power plant supplied both heating heat and hot water to the consumers; peak operation and periods see 1/d and 1/e [5—8].

b) *Peak operation in extraction-condensing power plants*

Peak operation in winter. In extraction condensing power plants, the central supply of hot water is warmed either by the regulated bleedings of the extraction condensing turbine or by steam taken from non-regulated bleedings. From the viewpoint of our examinations, the case, in which the central hot water is warmed in the heating turbine, but there is a condensing turbine too in the plant, falls in this same category.

Peak operation in such a case consists of cutting out the steam for heating during the periods of electric load (two hours in the morning and two in the evening) and making the so released steam expand in the condensing portion of the turbine ("negative" peak operation).

Depending on the method of feeding the heat quantity, the power plant is run as shown in Fig. 2.

3. The economics of peak operation

The economics of peak operation can be appraised from different aspects The problem may be approached, for instance, from the angle of first costs and running costs.

a) *First costs*

In this paper we shall refer to the economics of a heating power station in the Hungarian capital (Kelenföld), studied from three angles, respectively in three variants.

α) In the first case it was supposed that peak operation saved the expenditure of a base power station equal to the annual average increase in peak output. Carrying out the calculation with the usual methodology of a "complementary power plant", savings between 8 and 15 million Forints were achieved, depending on the mode of operation.

β) The second calculation variant appraised the increase in output through peak operation by the savings made in the cost of import electric power during the peak periods. This calculation, on the basis of rather cautious assumptions, resulted in savings running into 5 million Forints per year.

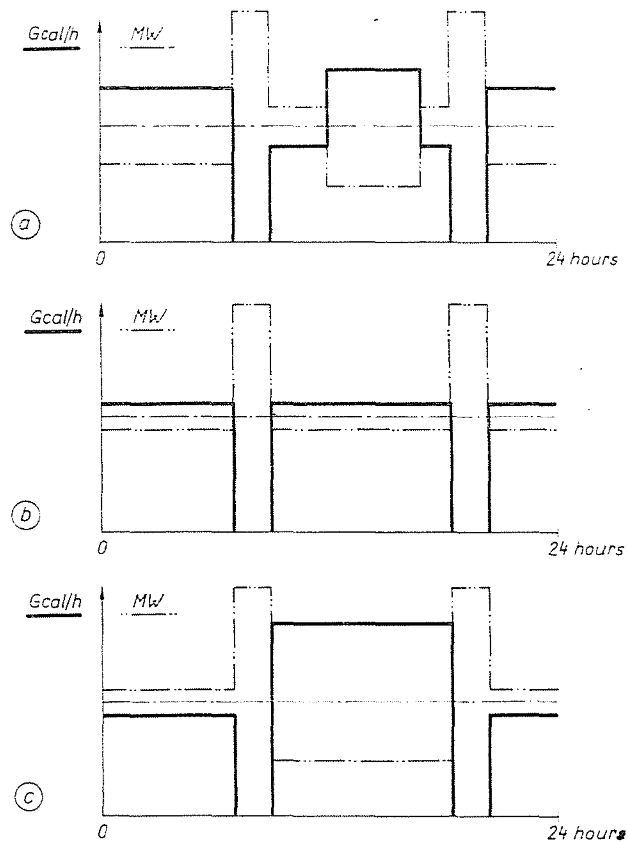

Fig. 2

γ) In the third variant, the savings achievable by peak operation were calculated for the case where peak operation could not be designed in advance, and the increase in output must be calculated on the basis of the increment costs in the Hungarian power station system. This calculation, for peak operation in summer by heating turbines, showed a 3 million Forint per annum saving.

Calculations, accordingly, unanimously proved that peak operation offers substantial economic advantages.

b) *Running costs charged on heating*

Another possibility is to determine the running costs which charge heating in heating power stations.

The running costs in function of the degree of the completion, for heating power plant, is indicated in Fig. 3.

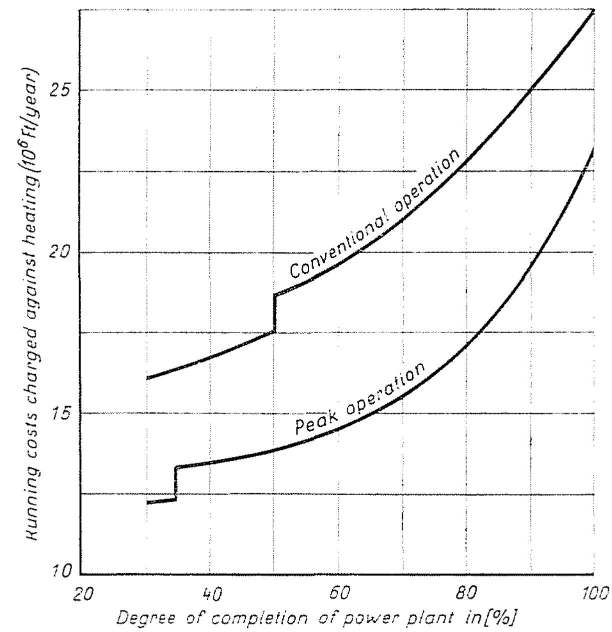

Fig. 3

The inflexions in the point of 50 per cent completion degree of the power station, in conventional operation, and in the point of 35 per cent degree of completion in peak operation, are due to the fact that in the respective management, the installation of the second power plant boiler becomes necessary at these very degrees of power plant completion, causing an $1 \cdot 10^6$ Forints/annum rise in the costs of personnel and maintenance [9].

4. Description of the measurements

Measurements during peak operation of power stations were carried out, under widely varying conditions, at the

Borsod thermal power station

Dunaújváros thermal power station

Kelenföld thermal power station
Pécs thermal power station.

a) Power plant types

Positive peak operation in a backpressure "heating turbine".
Negative peak operation in extracting condensing turbine.

In the course of each measurement, slight modifications were carried out even within the same group. One and two peak operations took place daily, lasting for two, resp. three hours. Both winter and summer conditions were measured.

b) Thermal centres

Two basic groups of thermal centres were examined:
buildings with heating only
buildings with hot tap water supply, too.

Since from the aspect of heating, the structure of the building is of considerable importance, conventional, block- and panel houses were examined.

Also the connection of the heating to the remote network was varied. We examined systems with direct, and indirect connection.

In combined heating and hot tap water supply systems, we examined the most diverse types of thermal centres: throughflow and storage type hot water producers; hot water producers connected in series and parallel with heating.

c) *Remote heating pipework*

From the aspect of remote heating systems, we examined pipes installed outdoors and underground systems, routed in concrete conduits.

The consequences of the new type of heating in winter and in the transition periods were measured at Borsod, Dunaújváros, Kelenföld and Pécs, the possible operational modes in summer periods were checked at the Kelenföld power station.

For lack of space, we shall abstain from describing the measurements and the findings in detail. We confined our treatment to giving a comprehensive picture in Table 1 and the conclusions drawn from the measurements [10, 11].

Table 1

Measurement series			Node of peak operation	Heat centres in housing estates	Method of measurement
Number	location	time of			
First	Borsod Thermal Power Station Kazincbarcika Békeváros	1966. Nov. 29 and Dec. 7	Negative	Indirect heating with series-connected storage type hot tap water producers	In the powerplant and its colony by means of recording instruments, in the city heat centre by reading
Second	Dunaújváros Thermal Power Station	1966. Nov. 14 and 23, Dec. 7	Positive	Direct heating with injector mixing. No hot tap water is supplied	In the power station and heat centres by means of recording instruments
Third	Kelenföld Thermal Power Station	1967. March 16, April 10, May 24	Positive	Indirect heating with different connections of the hot tap water supply	In winter in power plant and heat centre by means of recording instruments In summer, in power plant by recording instruments, in the heat centres by readings
Fourth	Pécs Thermal Power Station	1967. Nov. 11.	Negative	Indirect heating — no hot tap water supply	In power plant with recording instruments in heat centres by readings

5. Measurement results: Conclusions

My aim in the experiments with peak operation had been to examine its effect on the inside temperatures of the flats, on the supply of hot tap water, and upon the transmission pipeline.

a) *Inside temperature in the flats*

In the course of measurements, the trends in the temperature of the flats were measured. The flats were supplied heat from all known types of heat centres. The measurements, which extended to flats on intermediate floors, the ground floor, the top floor, in rows of rooms and corner rooms, proved that peak operation caused no measurable *difference* in the inside temperature of the rooms.

b) *Hot tap water supply*

From the measurements in the Kelenföld heat centres, I have come to the conclusion that in peak operation the temperature of hot tap water rises and that the hot water demand of the consumers can be covered at a higher temperature.

Higher temperatures had no detrimental consequences. No extra heat was consumed since the consumers needed less of the water available at higher temperatures. Accordingly, for the production of hot tap water, peak operation is not only permissible but advantageous, too.

c) *Heat losses and strength characteristics of the transmission pipelines*

The thermal losses of the transmission pipeline were very low and never surpassed the 2°C per kilometre, which was quite acceptable even in stationary operation. This shows that peak operation is admissible also from the point of view of heat losses.

No stability problem arose in either of the four heating power stations during the one and a half years of experimenting.

In the next (second part) regardless of the above measurement results, I wish to prove again, by calculations and deliberations, that both variants of peak operation outlined above are feasible without any sort of harm done to the consumers system and the transmission pipeline.

Summary

Changes in the structure of energy carriers and fast technical development have introduced new concepts in the building and running of heat supplying power plants.

A new and modern method for operation in the running of heat producing power plants during the electric peak periods. The paper deals with the indications, methods and potentials of electric peak operation, as well as the problems caused by peak operating from the consumers' angle.

In this framework, the author examined the trends in the temperature inside flats, the pattern of the temperature of hot tap water and the heat losses of the transmission pipelines.

The examinations were performed through measurements and theoretical deliberations. Both methods have proved that peak operation has no contraindications from the consumers' standpoint, and the potential economic advantages may, and should, be exploited.

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