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REFUSE INCINERATION—HEAT RECOVERY PLANTS: ENGLAND JAPAN

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Present Situation of Refuse Incineration in Japan and Problems in Utilization of its Waste Heat for District Heating and Other Purposes

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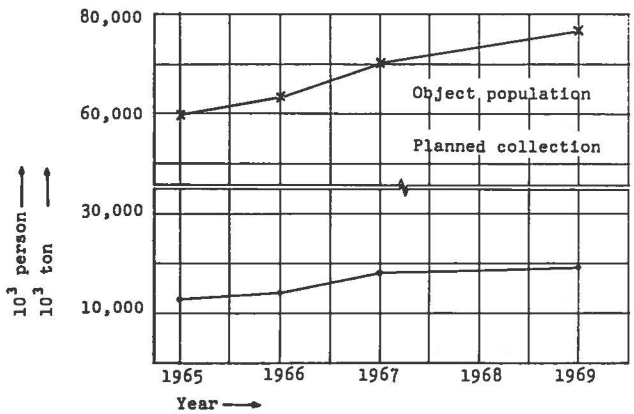

Fig. 1—Trends in planned collection of refuse for entire Japan.

Introduction

The disposal of waste matter in our environment is now a grave problem faced by all countries in the world. In particular, when future environmental pollution problems are considered, the simplest methods of disposal—dumping and land filling—will be greatly restricted, and switching to more sanitary ways of disposal will become obligatory.

Incineration, which is the most effective means of disposing of wastes (refuse), chiefly comprised of combustible matter already has a long history, and there are many kinds of innovations and studies for sanitary and safe incineration of refuse. The history of refuse incineration in Europe is especially long, and European techniques in this field are highly regarded and widely adopted in Japan. Further, power generation and heating using waste heat from refuse incineration are actively being carried out in Europe of recent, which also have been carefully watched from our country.

Refuse incineration is no longer merely a negative action for disposal of waste matter, and needless to say, it should be evaluated in a positive attitude as a source of energy. Particularly, in the case of Japan, the country is poor in energy resources while energy consumption is increasing sharply, and it has become a necessity for rational consumption of energy to be planned hereafter giving consideration to effective utilization of every source available. In this context, one of the most keenly noted approaches at this time is the utilization of waste heat at refuse incinerating plants.

This paper discusses the problems of refuse disposal, the present condition of incinerating facilities and the trend of waste heat utilization, estimates the heat potential of refuse, and further, comments on the utilization of the heat for district heating.

Refuse Problem in Japan

Although the problem of city refuse began to be brought up in Japan by a small number of knowledgeable persons in the early 1960's, public awareness regarding the matter has been awakened since only the last two or three years.

The urban structure in Japan has been very weak in regard to the energy balance of materials produced in the brisk societal activities of the modern age, namely, systems regarding supply of materials and the disposal of effluents. One of the problems concerning effluents (waste matter) is disposal of refuse.

Fig. 1 indicates trends in planned refuse collection quantities and populations considered in collection: the former increasing by 45.8 per cent in the four years from 1965 to 1969 (annual average of 11.5 per cent); and the latter increasing by 26.3 per cent during this time.

Among Japan's major cities in the past five years, the greatest increase in actual refuse collected was in Yokohama (200 per cent), and the lowest was in Tokyo (44.5 per cent). Yokohama also had the sharpest rise in population. Among refuse, other than residential garbage, industrial wastes pose serious problems, but residential wastes will chiefly be discussed herein.

In Tokyo, the governor, in September 1971, made a declaration of "War Against Refuse." This was first brought on by the repulsion of residents of Koto Ward in Tokyo, against the practice of the city over many years of dumping the entire city's refuse in part of the ward designated as a dumping ground. This opposition caused a serious obstacle to the future of refuse disposal in the city, and the declaration was a manifestation of the governor's positive posture in coping with the situation. The problem has not since been completely eliminated: it is gradually being solved through establishment of a principle by which disposal should be made within each ward as a result of discussions with the residents.

However, the dislike of residents for incineration plants is still very strong, and this continues to be a hindrance to location of plants. With rapid improvements recently made in plant quality, however, the problem appears to be changing to one of complaints against traffic congestion, objectionable odors, and swarming of flies, caused by garbage trucks in collecting and transporting refuse.

In any event, to cope with the explosive increase in refuse, not only are various methods of disposal being considered, but positive movements against production of refuse have been initiated and are being promoted in the form of self-imposed control on excessive packaging by department stores and shops, and recycling through recovery as paper and other resources.

Refuse Incineration Plants in Japan

Until about ten years ago, there was little social consideration given to disposal processes in the majority of refuse disposal plants, which were of inefficient types usually located in remote areas. There were also only a small number of specialists tackling the problems, and for a long time their efforts were not properly evaluated in society. However, with the increased seriousness of the refuse disposal problem mentioned previously, such work gradually began to draw public attention in Japan also, and in accordance, incinerating facilities have successively been modernized and large-scale incineration plants are actively being constructed.

Table I gives the situation in refuse incineration plants in Japan, showing there were 585 plants of all sizes as of 1970. It is thought that in regions with adequate refuse dumping areas, there will still be many years required for progress to be made in the direction of disposal by incineration.

The authors, for many years, have proposed and promoted utilization of heat from refuse incineration from their unique standpoint regarding the energy problems of Japan. The senior author described this in papers reported at the Fourth International Congress of Heating and Air Conditioning and the First International District Heating Convention. In recent years,

TABLE I

TOTAL NUMBERS OF INCINERATING PLANTS AND NUMBERS OF PLANTS UTILIZING WASTE HEAT IN PREFECTURES IN JAPAN

(From Sanitation Facilities Register 1970)

Prefecture	Total Incinerating Plants	Plants Utilizing Waste Heat
Hokkaido	6	5
Aomori	12	8
Akita	9	4
Iwate	15	7
Miyagi	7	4
Yamagata	14	7
Fukushima		
Niigata	22	13
Toyama	7	4
Ishikawa	11	4
Fukui	8	2
Nagano	14	9
Gifu	13	4
Shizouka	20	10
Aichi	30	16
Mie	13	5
Ibaragi	12	5
Chiba	20	12
Tokyo	29	21
Tochigi	18	10
Gunma	9	8
Saitama	23	12
Yamanashi	7	3
Kanagawa	31	19

Prefecture	Total Incinerating Plants	Plants Utilizing Waste Heat
Shiga	4	1
Kyoto	9	3
Osaka	30	22
Nara	11	7
Wakayama	5	3
Hyogo	30	7
Okayama	12	7
Hiroshima	12	5
Tottori	5	2
Shimane	7	2
Yamaguchi	12	7
Tokushima	4	1
Kagawa	5	1
Ehim	10	0
Kochi	9	4
Fukuoka	18	9
Saga	8	3
Nagasaki	11	5
Kumamoto	10	3
Oita	7	1
Miyazaki	7	0
Kagoshima	9	3
TOTAL	585	288

there has finally arisen a movement to utilize refuse incineration heat, and pertinent studies and planning are going on in various parts of the country. By around 1975, there should be a fair amount of actual cases which can be expected to be realized. The previously mentioned Table I indicates the numbers of facilities, by region, which are utilizing heat from refuse disposal in some manner, which amount to 49 per cent of the total incineration facilities.

Table II gives a breakdown of the facilities utilizing heat from refuse incineration, of which 88.5 per cent is used for plant operation, hot water supply, and heating and cooling inside plants; there still being very few cases of self-generation of electric power. Of heat supplied to the district society, 49 per cent is in the form of hot water supply, and other than one case now planned, there is only one plant utilizing heat for district heating (block heating in this case).

In case of plants presently under construction or being planned, there is seen a fair amount of increase in positive utilization of heat for generation of power to be used in-plant and for warm water swimming pools outside.

Trend in Utilization of Refuse Incineration Heat

The Bureau of Sanitation, Yokohama Municipal Office, has made trial calculations on the forms of refuse incineration heat utilization now being considered. There are various directions in which heat utilization may be considered to be pointed. In reality, there is the problem of location of plants in urban areas; and unless environmental programs stressing energy (as have been advocated by the authors) are carried out, the utilization rate of not only waste heat but of the plants themselves will be lowered. Especially, considering the high proportion of plumbing costs in equipment expenditures, it is desirable for plants to be as close as possible to where there is demand for heat; and in such a case as planning desalinization of sea water, a location where clean sea water is available.

A number of examples of uses and conditions of location are given below.

Sea water desalinization: coastal districts, places with clean sea water, districts expected to suffer shortage of water in the future. Locating of salt manufacturing plants also feasible.

Ice manufacturing plants, concrete production plants, laundry plants, industrial parks, factory areas.

District heating and cooling: commercial districts in cities, suburban residential developments, disaster-prevention and pollution-prevention districts in urban centers.

Warm water swimming pools, sports centers, old folks' homes, ice skating rinks, health centers: public facilities districts.

Hot houses: neighboring farm districts.

Further, Fig. 2 shows estimations of population by year from 1969 to 1980, refuse generation, total heat generation and other data for the above mentioned city of Yokohama. The numbers of households and areas where district heating would be possible in 1975 and 1980, according to these estimations, are as described below, provided that it would be possible for 50 per cent of the heat produced to be utilized, and assuming that heating time would be 18 hours, heating load 200 kcal/m^2 (floor area) hr including piping loss and average floor area of heating of 80 m^2 per household.

	Feasible Area of District Heating (m^2)	Feasible Number of Households in District Heating
1975	800,000	10,000
1980	1,530,000	19,000

TABLE II
BREAKDOWN OF WASTE HEAT UTILIZATION IN ENTIRE JAPAN IN 1970
(From Sanitation Facilities Register 1970)

Breakdown	Number of Cases
In-plant	
Operational	18
Services for crew:	
Hot water supply	334
Heating and air conditioning	59
Services to official residences:	
Heating	2
Hot water supply	2
District Society	
Services to district residents:	
Hot water supply to social welfare facilities	11
Hot water supply to district residents	11
Services to municipal facilities:	
Sewage treatment	17
Desalinization of sea water	1
Supply to private businesses	5
Concrete Uses Unknown	9
TOTAL	469

Heat Quantities Available for Utilization

Although, in the future, the amount of generation of refuse from both residential and industrial systems should increase further, and heat production from refuse should rise to a certain extent, for the present, the potential quantity of heat contained at this stage has been trial calculated from the viewpoint of utilization of incineration heat. However, beginning with central government offices, there are few agencies possessing definite data, so that studies were made based tentatively on officially published data, but with assumptions within ranges which are not unreasonable for the present stage. It should be noted that the amount of refuse generated, and the amount of refuse collected, do not necessarily agree, it being common for the latter to be increased as collection is carried out more thoroughly.

There are no everyday data on quantities of heat generated from refuse outside of regions equipped with inspection capabilities, and in this case there is no other course but to make assumptions, but according to the opinions of experts, it is said there is not so much difference by region.

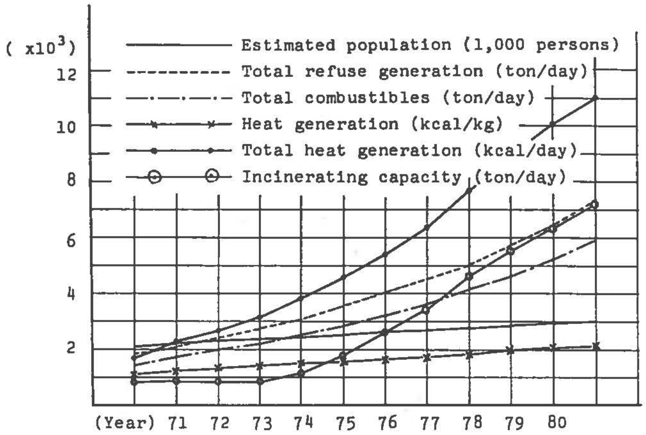

Fig. 2—Refuse incineration plan and estimations of heat generation, etc. in Yokohama in future.

The hypothetical values in these trial calculations are as indicated below:

Incineration disposal ratio (avg) = 70% (correction factor in case of differing value)x_1% : $x_1/70$ (effective heat generation ratio) =

$$\frac{[\text{total quantity of heat possible to utilize (kcal)}]}{[\text{total quantity of refuse incinerated (kg)}] \times [\text{avg lower calorific value of refuse (kcal/kg)}]}$$

(= assumed to be 77% according to trial calculations by Yokohama Municipal Office; correction factor in case of differing value x_2% : $x_2/77$)

(heat quantity possible to utilize outside) = (total quantity of heat possible to utilize) - (heat quantity consumed in plant) (= assumed to be 87% according to trial calculations by Yokohama Municipal Office; correction factor in case of differing value x_3% : $x_3/87$)

Lower calorific value of refuse = 1000 kcal/kg (correction factor in case of differing value x_4 kcal/kg : $x_4/1000$)

Refuse generation quantity = 700 gr/person/day (correction factor in case of differing value x_5 gr/person/day : $x_5/700$)

Future of Utilization of Refuse Incineration Heat

Although the utilization of heat from refuse incineration has only just been started in Japan, interest in this has recently increased sharply and plans in this connection have been reported from various regions. However, the relation between incineration disposal and nature of refuse is important, and when recovery of paper and other resources from domestic refuse is started in earnest, it is thought assumption of the future based on past estimation curves will be difficult. Therefore, as a provision on the safe side for the moment, the authors have considered that the situation would hereafter proceed at the present tempo to a certain stage, and in the event there should be a lowering of calories in domestic refuse, compensation would be made with a different kind of refuse (for example, relatively harmless and high heat-evolving plastics).

In any event, the incineration disposal method should prevail for a considerable length of time, added to which, in the case of large-scale plants, based on the reality that a period of two to three years would be

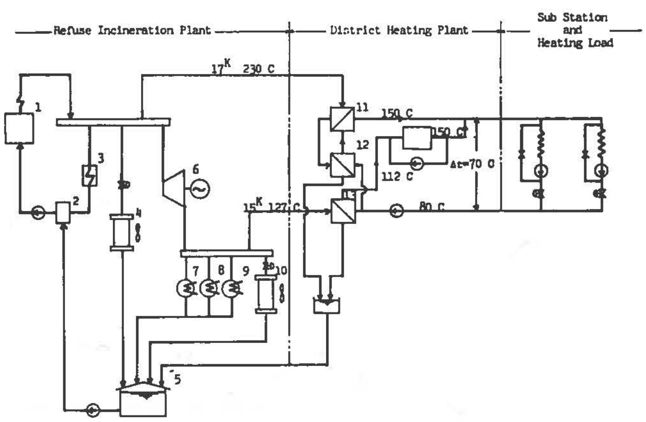

Fig. 3—Overall system diagram: (1) Waste heat boiler (2) Deaerator (3) Steam air heater (4) High pressure condenser (5) Condensing tank (6) Turbine generator (7) Heat exchanger, road heating (8) Heat exchanger, heating (9) Heat exchanger, hot water (10) Low pressure condenser (11) High pressure heat exchanger (12) Intermediate heat exchanger (13) Low pressure heat exchanger.

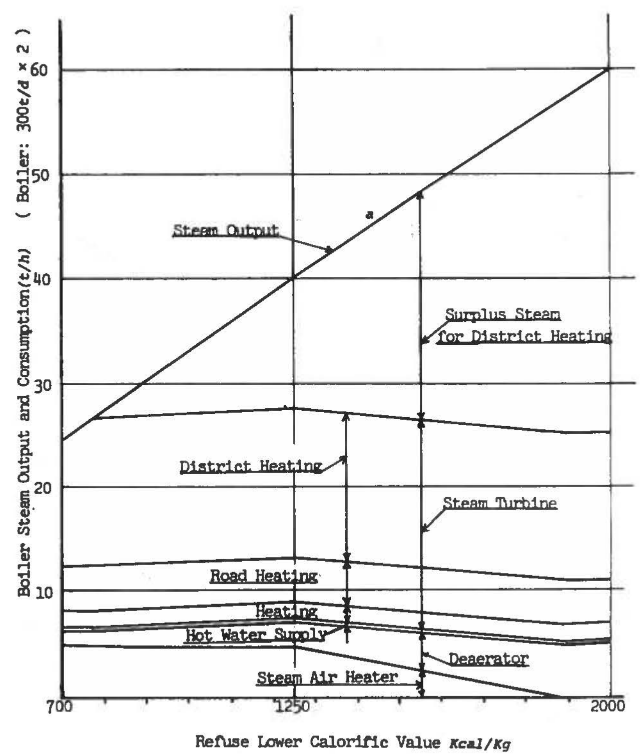

Fig. 4—Winter steam generation and consumption for two furnace units.

required from the planning stage to start of operation, a sudden change in policy would be difficult. This paper is predicated on the assumption that disposal of refuse through incineration will continue. There are numerous social problems related to incinerating plants and careful consideration should be given to the matter.

At present, there are almost no concrete examples of full-scale utilization of heat from refuse incineration for district heating, but one case of an actual small-scale plant and two cases planned for future construction will be introduced.

One is a project completed in February 1969 at the Morinomiya District in Osaka, the outline of which is:

Disposal capacity: 300 ton/24 hr x 3 = 900 ton/24 hr

Garbage lower calorific: 1100~1500 kcal/kg value (evaporation multiple of waste heat boiler: 1.35 ~1.4 ton/t refuse)

Total construction cost including land acquisition: $7,140,000

Heat supply: 4.7 Gcal/hr (13.5 atg 230 C)

Farthest distance to outdoor heat supply pipeline: 1 km (approx.)

Another is the Nopporo Housing Site at the outskirts of Sapporo, Hokkaido, which is scheduled to be constructed shortly. Data from the study on this district heating project are given in Figs. 3 and 4.

Conclusions

The present situation of refuse incineration in Japan, and the problems of utilization of heat for district heating and other purposes, have been described in the foregoing. As stated at the beginning, the rational and effective utilization of various types of energy, with the background of the energy resources problem, is considered to be a most important and pressing matter. It is from this standpoint that the authors have focused their attention on the waste heat from refuse incineration as a source of urban energy.

A period of six years has already passed since the senior author presented a paper on this problem at the Fourth International Congress of Heating and Air Conditioning of 1967. During this time, interest in utilization of this heat has gradually increased, but as mentioned in this paper, full-scale applications are still very few in number. This is particularly so in application to district heating. However, this is presently the stage of transition to heat utilization, and it is believed there will be considerable progress made in the coming several years.

Acknowledgments

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(Ed. Note: This paper was originally presented at the Second International District Heating Convention in Budapest, Hungary in May 1973.)

Member Company Commentaries

B I F, A Unit of General Signal Corp.
West Warwick, R.I.

On April 3, B I F dedicated its new $10 million office and manufacturing facility in West Warwick (the Company headquarters was formerly in Providence). The new plant, which occupies an 82-acre site, is reported to be the largest and most modern in the nation devoted to the advancement of flow technology, and the manufacture of water pollution control equipment. Speaking at the dedication ceremonies, Company President Arthur Herrmann, Jr. said that the number of orders received during the first quarter of 1974 was the greatest in Company history.

Established in 1820, the company that is now B I F was originally the High Street Furnace Company of Providence. Later, it was reorganized and incorporated as Builders Iron Foundry (B I F). The foundry was engaged in manufacturing a wide variety of grey iron castings such as architectural fronts, window frames and hollow cast-iron columns for the building frames.

In 1893, the Chief Engineer of B I F, F. N. Connet, perfected the necessary metering instruments for the famed "Venturi Flow Tube" developed by Clemens Herschel six years earlier. The combination, known as the "Venturi Meter," was an outstanding scientific first in the field of flow measurement. It also marked the beginning of a long series of firsts from B I F. Among them was the first electric filter control system for water treatment plants, devised in 1937; the first automatic device for gravimetric water sterilization in 1943; and the Universal Venturi Tube, developed by Desi Halmi of B I F in 1970.

By 1953, the Builders Iron Foundry changed its name to B I F Industries, Inc., because customers found it difficult to associate an iron foundry with its highly engineered products. Today, B I F, A Unit of General Signal, is recognized world-wide as a leader in automatic flow control, in the controlled feeding and weighing of liquids and solids, and in waste treatment systems.

(To 28)