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フイリピン共和国

メトロマニラ火力発電所

リハビリテーション

計画調査報告書

（付　録）

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APPENDICES

APPENDIX-1 MANAGEMENT OF PERFORMANCE

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Efficiency of thermal plant was rapidly improved during a period from 1955 to 1970 in consequence of progress of technology such as improvement of steam conditions and introduction of big capacity plant etc.
Progress of efficiency in Japan is shown on the Fig. 1.
Improvement of thermal efficiency is one of the important objectives of study for the country which imports almost all energy resources.

1. Heat balance

   Heat balance is provided in order to recognize the utilized factor of heat input. Heat input and output are calculated each item i.e. the process of generation absorption and loss etc. of heat are analyzed and calculated so as to be known on heat distribution.
   An exsample of heat balance diagram of a thermal power plant is shown on the Fig. 2. This diagram is important for judgement of operating conditions and to study for improvement of thermal efficiency.
   Evaluation of heat balance should be carried out by judgement of thermal efficiency mainly. An exsample of calculation of thermal efficiency is shown as follows.

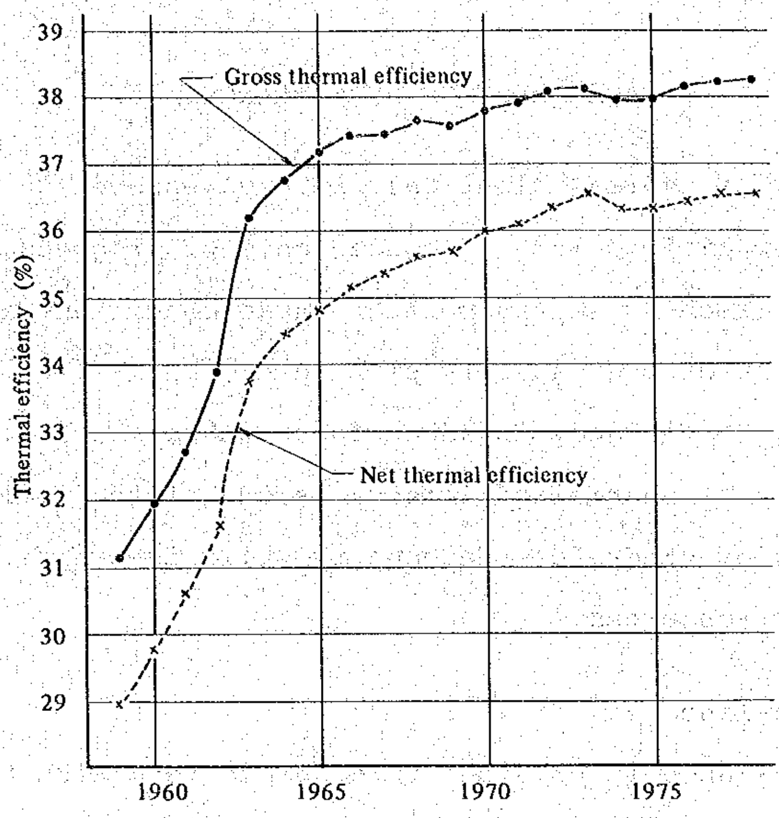


Fig. 1 Progress of thermal efficiency in JAPAN

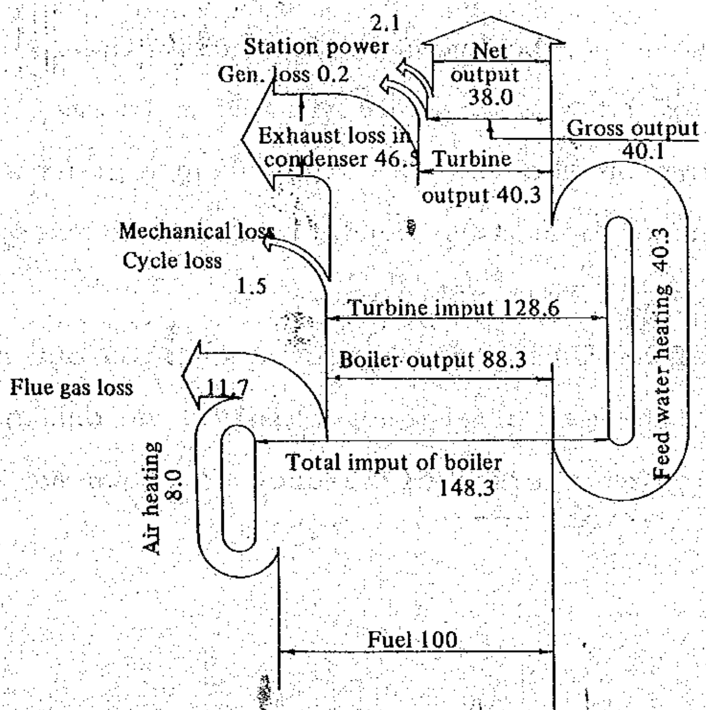


Fig. 2 Heat balance diagram (Example)

(1) Thermal efficiency of unit

Thermal efficiency of thermal plant is rate of generated power and heat of fuel consumed. That is:

$$\eta PG = \frac{PG \times 860}{B \times Hh} \times 100\% \qquad (1)$$

$$\eta PN = \frac{(PG - Ph) \times 860}{B \times Hh} \times 100\% \qquad (2)$$

where:

ηPG : Gross thermal efficiency [%]

ηPN : Net thermal efficiency [%]

Pg : Generated power [kwh]

Ph : Station service power [kwh]

B : Fuel consumption [kg/h]

Hh : Higher calorific value [kcal/kg]

Gross thermal efficiency which is computed with generated power at generator terminal and which is also multiplication of boiler and turbine efficiency as indicated by formula (1).

Net thermal efficiency is computed on output that station service power is deducted from generated power at generator terminal.

As for calorific value of fuel, there are higher calorific value and lower one, and generally, the former is adopted for computation.

(2) Effeciency of turbine cycle

Efficiency of turbine cycle is a rate of generated power and quantity of heat absorption in turbine cycle. Where heat absorption in turbine cycle is QT [kcal], efficiency of turbine cycle, ηT is:

$$\eta T = \frac{Pg \times 860}{QT} \times 100 \; [\%] \qquad (3)$$

In the case of a reheat turbine

$$QT = G_1 h_1 + GR\,(hR - hr) - Gwhw - ghg.$$

where,

G_1	:	Steam flow to turbine	[kg/h]
h_1	:	Enthalpy of main steam	[kcal/kg]
GR	:	Reheat steam flow	[kg/h]
hR	:	Enthalpy of higher temp. reheat steam	[Kcal/kg]
hr	:	Enthalpy of lower temp. reheat steam	[Kcal/kg]
Gw	:	Feed water flow to boiler	[Kg/h]
hw	:	Enthalpy of boiler feed water	[Kcal/kg]
g	:	Steam flow to outside of turbine plant	[Kg/h]
hg	:	Enthalpy of steam to outside of turbine	[Kcal/kg]

(3) Efficiency of boiler

Boiler efficiency is a rate of net heat quantity supplied to the turbine cycle and calorific value of consumed fuel.

Boiler efficiency, ηB is:

$$\eta B = \frac{QT}{B \times Hh} \times 100\% \qquad (4)$$

(4) Heat rate

Heat rate is necessary heat value for power generation of 1 kwh and the unit is kcal/kwh or Btu/kwh.

$$HR_{PG} = \frac{B \times Hh}{Pg} \qquad (5)$$

$$HR_{PN} = \frac{B \times Hh}{Pg - Ph} \qquad (6)$$

where,

HR_{PG} : Gross heat rate
[kcal/kwh] or [Btu/kwh]

HR_{PN} : Net heat rate
do.

B : Fuel consumption
[kg/h] or [lb/h]

Pg : Generated power
[kwh]

Ph : Station service power
[kwh]

Hh : Higher calorific value
[kcal/kg] or [Btu/lb]

Relation between thermal efficiency and heat rate is:

In the case of [kcal/kwh]

$$\eta_{PG} = \frac{860}{HR_{PG}} \times 100 \qquad (7)$$

$$\eta_{PN} = \frac{860}{HR_{PN}} \times 100 \qquad (8)$$

In the case of [Btu/kwh]

$$\eta PG = \frac{3412}{HR_{PG}} \times 100 \qquad (7)'$$

$$\eta PN = \frac{3412}{HR_{PN}} \times 100 \qquad (8)'$$

2. Performance Control/Management

The most important thing to control/manage thermal power plants is always to supervise and correctly to comprehend the plant operating conditions for improvement of thermal efficiency. An example of the control/management method is described as follows:

(1) Management for target value

As an important means for grasp of performance, there is a means called as target value management. In this case, deviation between actual value and predetermind value is managed. Target values are also called as standard values which are obtained or expected on condition that equipments are running without any abnormality. These values are set depend on the operation data during trial operation of plant and design data. Target values are corrected depend on the actual operating condition sometimes.

There are two kinds on these value. One is operating condition such as temperature, pressure etc. and another is preformance data such as unit efficiency, boiler efficiency etc. The latter is changed depend on the outside condition so that data have to be corrected. This correction should be done depend on correction curve submitted by manufacturer, generally.

(2) Management of tendency

Operating conditions have to be grasped according to the operating conditions of every day and main items which effect the plant efficiency should be indicated by graph, for daily, weekly and monthly data in order to be observed on their tendency.

Items to be managed are considered as follows.

- Generator out-put
- Main steam temperature and pressure
- Reheat steam temperature and pressure
- Flue gas temperature (Air Heater Outlet)
- Boiler metel temperature (Maximum point of each Section)
- AH average temperature
- Boiler feed water temperature (Econorizer inlet)
- Condenser vacuum and cooling water temperature

(3) Performance before and after annual overhaul.

Performance tests should be performed before and after annual overhaul in order to evaluate the measures for improvement of performance. And operating conditions of equipment should be also recorded in order to judge effect of annual overhaul.

3. Coutermeasure for deterioration of plant performance

Almost all losses in the thermal plant are flue gas loss and condenser loss as indicated on the heat balance diagram (Fig. 2).

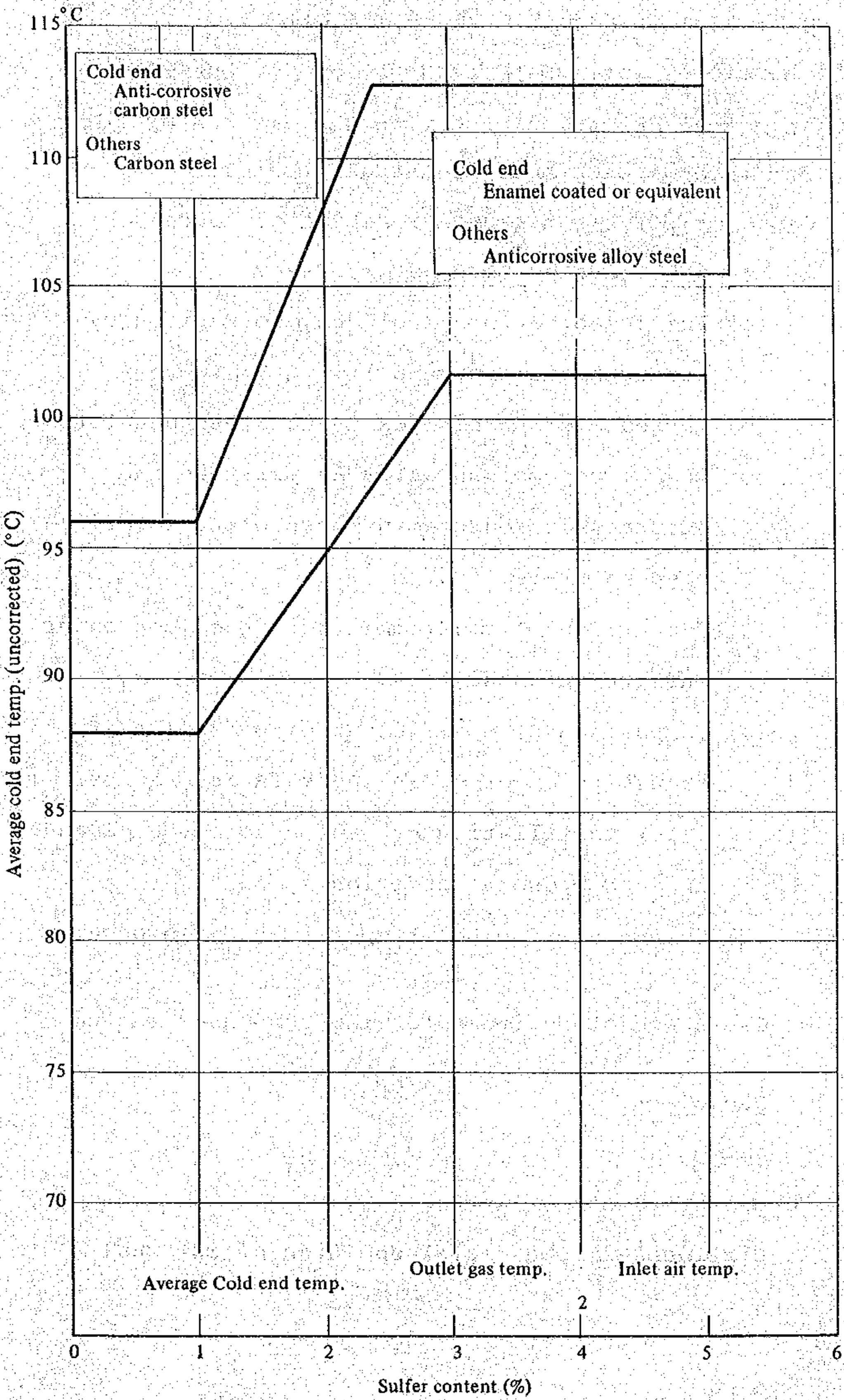
Therefore, major items for plant performance are management of flue gas temperature and condenser vacuum in order to maintain higher plant efficiency.

(1) Flue gas temperature

In order to reduce flue gas loss, flue gas temperature should be decreased as low as possible but if temperature of gas is decreased too low, the air preheater element will be corroded and clogged. It is recemmended that air heater average cold end temperature is maintained as indicated on the Fig. 3 in order to prevent corrosion on cold end and to get higher efficiency.

However, there may be dew partially on the cold end element because of ununifermed distribution of temperature of steam coil heater, and because that temperature indications of air heater

Fig. 3 Minimum average temperature for cold end of air heater (Recommendation for corrosion prevention)



gas and air are not covered all places.
Therefore, optimum temperature should be decided in actual operation observing the air heater cold end through peep hole of the air heater.

(2) Cause of performance deteriozation of condenser

a. Items to be confirmed before study

(a) Instrument error (including correction by atomospheric pressure.)

(b) Increase of turbine exhaused steam quantity

(c) Change of cooling water temperature and accuracy of measurement of cooling water temperature.

(d) Comparison of performance curve of condenser and present condition.

(e) Comparison of coefficient of overall heat transmission or cleanliness factor at just after installation or just after tube cleaning and present condition.

(f) Change of terminal temperature difference.

b. Cause and study items for low condenser vacuum.

Phenomena or cause	Study items
Condenser	
1. Dirtiness of tube	(a) Inspection of internal

	surface of tubes (1) (2) (3)
(1) Slow deterioration of condenser vacuum	(b) Inspection and analysis of deposit (1) (2) (3)
(2) Increase of pressure loss	(c) Change of pressure loss and terminal temperature difference (Check operation log sheet) (2) (3)
(3) Increase of turminal temperature difference	(d) Computation of cleanliness factor and coefficient of heat transmission (1)

2. Shortage of cooling water

(1) Increase of cooling water temperature difference between inlet and outlet	(a) Study of cooling water quantity by perfermance curve (1) (2) (3)
	(b) Plugging of tube (2)
	(c) Deterioration of circulating water pump performance or low frequency of power etc. (3)
(2) Increase of cooling water pressure difference between inlet and outlet	(d) Clogging of cooling water line. screen strainer and other associated equipment (2)

(3) Decrease of cooling water pressure difference between inlet and outlet	(e) Check of airvent valve and water level gauge of upper water chamber (4)
	(f) Study of siphon effect. (4)
(4) Air accumulation in water chamber upper portion.	
3. Change of cooling water temperature and quality	(a) Check of depth of water intake channel.
4. Air leak	
(1) Increase of air meter indication	(a) Check of leak on the vacuum zone of turbine exhaust, connection of condenser and turbine and bled steam.
(2) Delay of vacuum up during start-up	There is seldam leak at holizontal connection of turbine casing. (Check by fleon gas leak detector)
(3) Rapid drop of vacuum during shut down	(b) Check of leak on associated equipment such as drain trap

	valve level gauge, provided on the feed water heater in vacuum zone.
	(c) Leak of gland steam
	(d) Defect of discharge device to atomosphere.
	(e) Leak test by water filling
5. Raising of hot well level	(a) Deterioration of condensate pump performance
	(b) Check of level control system
	(c) Defective water level gauge (Clogging, leak)
	(d) Abnormal condition of suction side of condensate pump (Corrosion of impeller, leak of gland, plugging of balance pipe etc.)
6. Air ejector	
(1) Shortage of steam press. and steam flow	(a) Check of valve opening and pressure gage. (1)
(2) Increase of air leak	(b) Check of nozzle and strainer clogging. (1) (3)
(3) Shortage of cooling water (condensate)	(c) Check of change of air meter and confirmation of leak point by fleon gas, during operation. (2)

(4) Break of seal of first stage drain line

(5) In sufficient draining of second stage.

(6) Increase of discharge air pressure.

(7) Clogging and wearing of nozzle and difuser

(8) Reverse flow of air

(9) Dirty cooling tube

(10) Fluctuation of steam pressure.

(d) Check of cooling water (condensate) temperature and pressure. (3)

(e) Check of condensate recirculation control (3)

(f) Check of first stage U tube level gage. temperature and clogging. (4)

(g) Check of second stage drain line clogging and steam trap. (5)

(h) Check of valve and piping of air discharge side. (6)

(i) Overhaul of nozzle and diffuser (7)

(j) Check of tube plate and packing etc. (8)

(k) Faulty operation of diffuser valve and leak. (8)

(l) Inspection of cooling tube, and pin hole check of portion at drain level. (9)

(m) Check of mixture of drain in steam (small fluctuation of pressure) and pressure gage. (10)