7.4 Combustion control and energy saving

7.4.1 The meaning of combustion control [1]

Combustion control refers to the operation of combustion furnaces so that the combustion efficiency is improved by rationalizing the combustion method and equipment maintenance.

In the time when coal was the primary fuel the main purpose was for heat economy and to prevent soot, but in the time of liquid fuels the primary factor of combustion control is the quality of the design of furnaces which use automatic combustion controls.

Also, because of the photochemical smog problem, combustion control must also take into account control of NOx creation, and fuels, furnaces and combustion technology have been improved.

7.4.2 Trends in combustion control and energy saving in Japan

(1) Application of low air fuel ratio combustion

The measurement and control of oxygen concentration in the burnt gad have been energetically used to properly control the amount of excess air, achieve complete combustion and reduce the amount of heat loss by exhaust gas. That is, reducing the amount of heat retained by excess air by reducing the amount of air in the furnace. In principle, as shown in Fig.7.4.1 [2], heat loss from unburned CO and H_2 is caused by insufficient air, and heat loss is also required to heat the excess air, so by controlling burning to the minimum amount of oxygen the total heat loss is minimized. However, currently the oxygen control target is higher than the minimum levels because of the problem of intruding air.

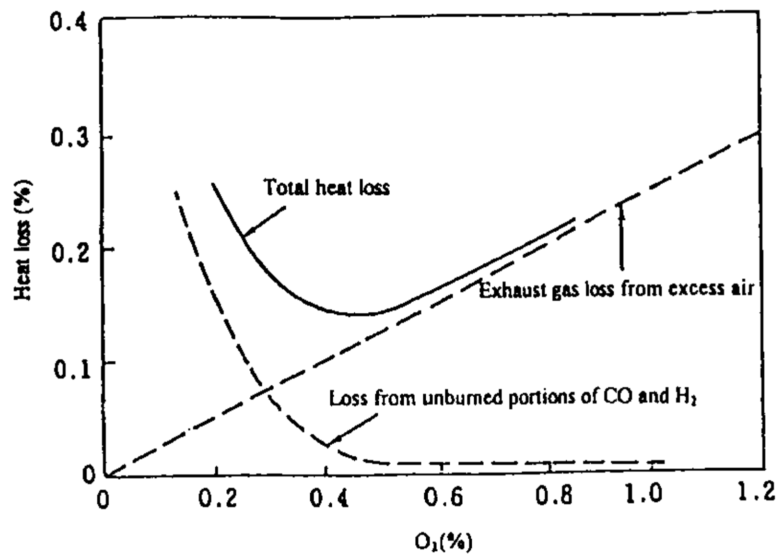


Fig.7.4.1 Relationship between O_2 concentration and total heat loss

Table 7.4.1 [3] shows the standard air fuel ratio for various furnaces. By targeting these various levels we should burn using low air fuel ratio combustion to rationalize energy saving to the extent technically possible.

Table 7.4.1 Standard air fuel ratio

(1) Boiler

Section		Load ratio (%)	Standard air fuel ratio			
			Solid fuel	Liquid fuel	Gaseous fuel	Blast furnace gas and other by product gasses
Electrical power industry use		75~100	1.2~1.3	1.05~1.1	1.05~1.1	1.2
Other	Amount of steam in excess of 30 t per hour	75~100	1.2~1.3	1.1~1.2	1.1~1.2	1.3
	Amount of steam more than 10 t but less than 30 t per hour	75~100	—	1.2~1.3	1.2~1.3	—
	Amount of steam less than 10 t per hour	75~100	—	1.3	1.3	—

(2) Industrial furnaces

Section	Standard air fuel ratio
Metal casted melting furnaces	1.3
Continuous steel slab heating furnaces	1.25
Metal heating furnaces other than continuous steel slab heating furnaces	1.3
Continuous heat treatment furnaces	1.3
Gas generating furnaces and gas heating furnaces	1.4
Fuel oil heating furnaces	1.4
Thermal resolution furnaces and improved quality furnaces	1.3
Cement kilm	1.3
Aluminum and lime calcination furnaces	1.4
Continuous glass melting furnaces	1.3

By using low air fuel ratio combustion heat loss by exhaust gas is reduced and we can reduce the amount of fuel consumed. Furthermore, with less combustion air and less exhaust gas, forced draft fans (FDF) and induced draft fan (IDF) are used less, so operation costs are reduced.

In addition, low air fuel ratio combustion is effective for the following measures, and are implemented as part of combustion control.

① NOx

Because of the low concentration of oxygen in the combustion the creation of NOx can be controlled.

② Low temperature corrosion

With low air fuel ratio combustion, by controlling the oxidation reaction from SO_2 to SO_3, the creation of SO_3, which causes low temperature corrosion, can be relatively reduced.

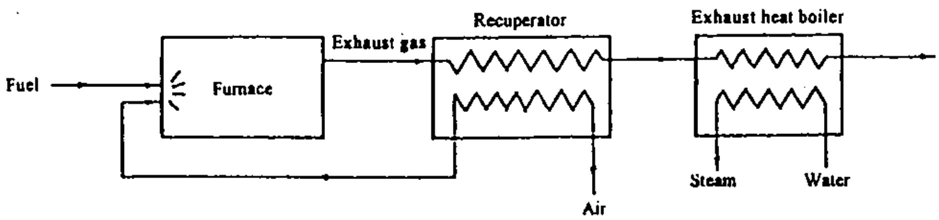
③ Acid smat

By burning fuel the soot created becomes a nucleus, and the sulfur in the fuel is absorbed in the sulfuric acid soot through burning, and frost forms at a temperature close to the fuel gas dew point, which is called acid smat. If low air fuel ratio combustion is used the creation of SO_3 and sulfuric acid are controlled, creating less acid smat.

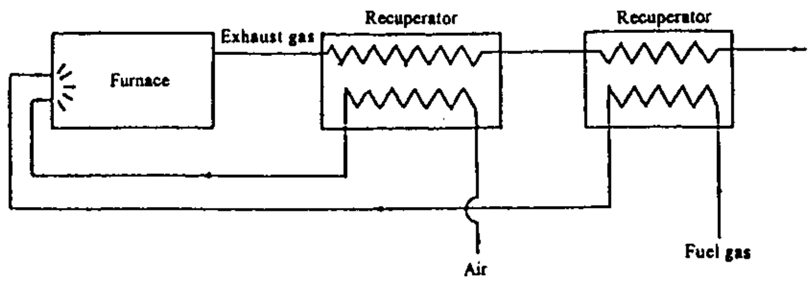
(2) Preheating of combustion air and gaseous fuel.

An effective method for addressing energy saving is close at hand at the furnace; preheating the unheated combustion air or fuel using waste heat. Currently however, mostly combustion air is preheated. Preheating of fuel should be undertaken upon sufficient consideration of thermal decomposition and safety, especially liquid fuels are not preheated for energy saving, except for being preheated to the most suitable evaporation temperature. Accordingly, preheating fuel for energy saving is limited to gaseous fuels.

Preheating air or gaseous fuels uses a recuperator (exhaust heat recovery heat exchanger). Recuperators are made from metal or tile (ceramic), the heat from the exhaust gas passes through a partition and is transferred to the air or gaseous fuel. An example of the arrangement of heat recovery by a recuperator is shown in Fig.7.4.2 [4].



(a) When increasing creation of steam in the exhaust boiler by preheating the combustion air



(b) When preheating both fuel and air

Fig.7.4.2 Sample arrangement of exhaust heat recovery with a recuperator

(3) Recent developments in energy saving

Technology to make a large impact on energy saving in industrial furnaces area, a regenerative burner system has been developed [5]. This technology recovers more than 80% of exhaust heat in industrial heating furnaces and is very effective for energy saving, enabling an almost 50% fuel reduction. Also, the low NOx combustion technology, FDI (Fuel Direct Injection) combustion has been developed which can sufficiently use highly pre-heated air.

In the thermal electric power area, efforts are being made to increase the output scale and improve thermal efficiency, and especially for improving heating efficiency is important to control the amount of CO_2 emission output in addition to lost heat. When burning fuel in compressed air combustion gas is created, and this expansive power is used to turn the gas turbine which creates electrical power, and the remaining heat from the gas turbine is used to turn a steam turbine. This combined cycle power generation is said to be 48-49%, more efficient than traditional thermal electric power generation. Also, in the case of burning coal, we are trying to introduce new technology for pressurized fluid boiler and compound coal-gas electric generation.

7.4.3 Items to mention

Using the second oil shock as an opportunity, Japan's untiring efforts regarding energy saving continue, but recently more efforts are required to improve thermal efficiency with regard to CO_2 countermeasures. Producing a combined form of second generation energy which has at least 2 types of useful energy from one source, and the adoption of a cogeneration system to supply energy is one option.

In developing countries in general the average thermal efficiency is about 30%, so there is much room for improving utilization of lost energy. These countries should first implement measures for low-air fuel ratio combustion and exhaust heat recovery. By doing this they will be able to significantly reduce energy lessened at the same time energy costs.