Third International Conference on Sustainable Construction Materials and Technologies http://www.claisse.info/Proceedings.htm

The State of Conservation of Energy and Usage of Wastes in Cement Plants in Japan

Shigeru TAKAHASHI[1], Hiroyuki ANZAI[1*] and Naoki AOKI[1**]

[1] *Production & Environment Dept., Japan Cement Association, Japan*
1-9-4 Nihonbashihoncho, Chuo-ku, Tokyo, 103-0023 Japan
[1] *shigeru-takahashi@jcassoc.or.jp*
[1*] *hiroyuki-anzai@jcassoc.or.jp*
[1**] *naoki-aoki@jcassoc.or.jp*

ABSTRACT

The cement industry is one of the typical energy-intensive industries. So, the conservation of energy to product cement clinker and cement is very important. This paper describes the transition of the specific heat energy, the specific amount of used wastes and the specific CO_2 emission of Japan's cement industry. In the "Keidanren voluntary action plan on the environment", heat energy and CO_2 emission are assessed except heat energy and CO_2 emission by using wastes. This paper describes the reasons about it, too.

Keywords. cement plants, heat energy, electric energy, wastes, CO_2 emission

INTRODUCTION

The cement industry is one of the typical energy-intensive industries. So, the conservation of energy to product cement clinker and cement is very important. The cement industry of Japan participates in the "Nippon Keidanren voluntary action plan on the environment", and the cement industry of Japan has held up the target for energy conservation.

This paper describes the state of conservation of energy and usage of wastes in cement plants in Japan.

PROCESSES OF CEMENT MANUFACTURE

The processes of cement manufacture are shown in Figure 1. At raw materials process, raw materials of cement clinker are prepared by granulating the mixture of limestone, clay, silica stones, iron oxide and the others in raw grinding mill. At burning process, cement clinker is manufactured. At finishing process, cements are produced by granulating finely the mixture of cement clinker and calcium sulfate in cement grinding mill.

The ratio of energy at each process is shown in Table 1. Most of heat energy is used for manufacturing of cement clinker in the burning process. The electricity energy is used in an about the same ratio. In raw material process, it is used for granulating raw materials of cement clinker. And, in finishing process, it is used for granulating the mixture of cement clinker and calcium sulfate.

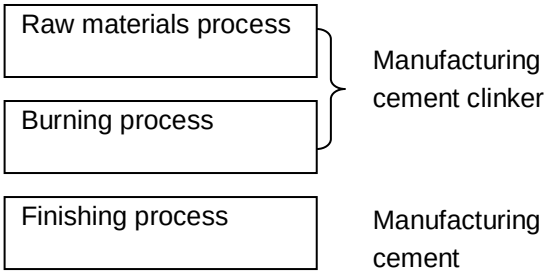


Figure 1 Processes of cement manufacture

Table 1 Ratio of energy at each process

Energy type	Raw material process (%)	Burning process (%)	Finishing process (%)
Heat	0	98	2
Electricity	30	33	37

ENERGY OF CEMENT MANUFACTURE

Heat Energy. The typical use of heat energy in clinker burning process is shown in Figure 2. The ratio of used energy to input heat energy is about 80 percent. 53 percent of input heat is used for burning of cement clinker and 18 percent of input heat is used for waste heat power generation.

The ratio of waste heat to input heat is 20 percent. Therefore, “Saving heat energy“ means “Decreasing waste heat energy“.

The transition of the diffusion ratio of the total of suspension preheater(SP) and suspension preheater with calciner(NSP), and the specific gross heat energy are shown in Figure 3. The conversion of kiln system to SP or NSP type has completed in 1997 in Japan. The introduction of SP or NSP led remarkably the decrease of the specific gross heat energy. But, the decrease of the specific gross heat energy has been little since 1997. After 2005, the specific gross heat energy increased little by little.

As one of the reasons it is considered that the using amount of the wastes which contain a lot of water has increased.

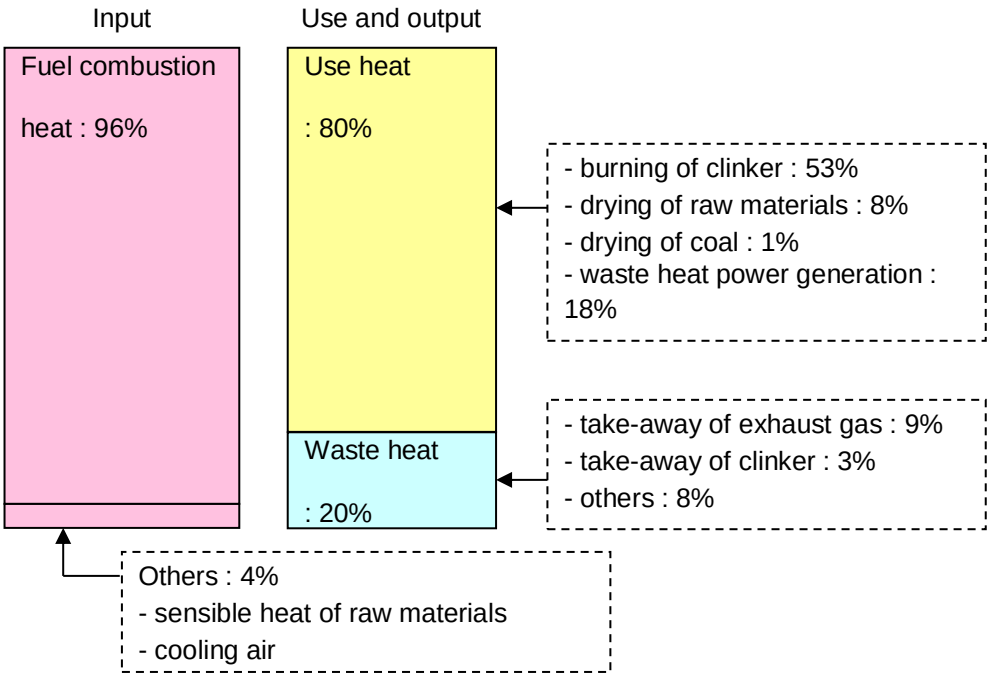


Figure 2 Heat energy in clinker burning process

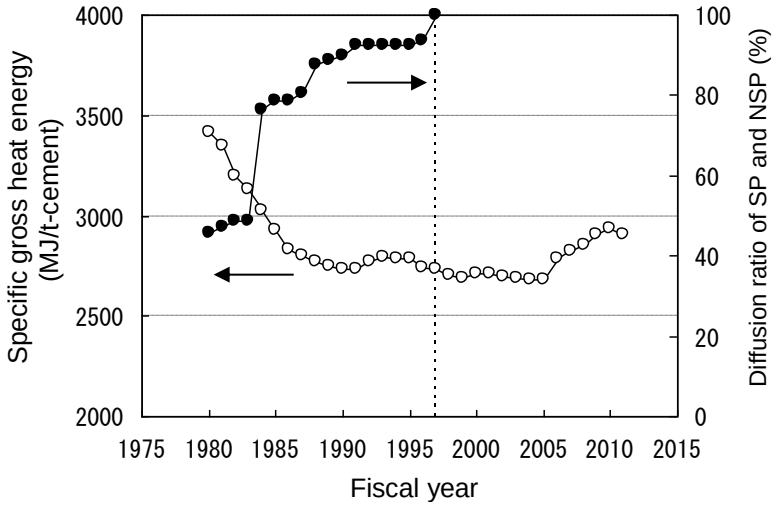


Figure 3 Transition of the diffusion ratio of SP(NSP) and the gross heat energy for cement manufacturing

Electric Energy. The transition of the specific electric energy is shown in Figure 4. The specific electric energy tends to increase year by year.

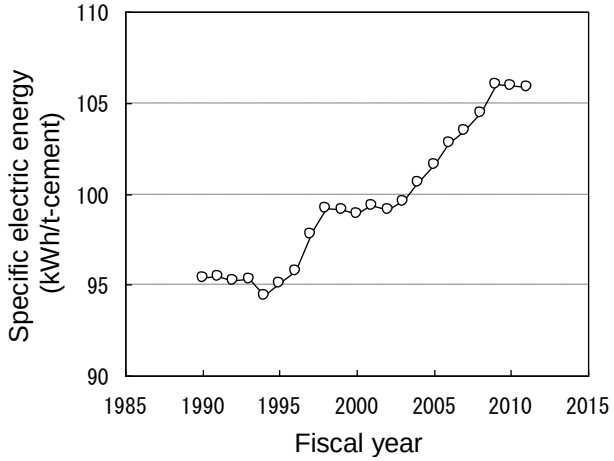


Figure 4 Transition of the specific electric energy

USE OF WASTES

The cement industry has used a lot of various wastes and by-products. But, the terms of "waste" and "by-product" are not defined clearly.

Japan Cement Association (JCA) reports the amount of used wastes and by-products every year (JCA, 1996)(JCA, 2001)(JCA, 2006)(JCA, 2012). In these reports, blast furnace slag or coal ash is used for both raw materials and admixture. But, this paper arranges wastes and by-products by "Main purpose". The kinds of wastes and by-products and the main purposes are shown in Table 2.

Table 2 Kinds of wastes and by-products and main purposes

Main purpose	Kind	
Alternative raw materials	- Coal ash	- Non-ferrous slag
	- Sewage sludge, Sludge	- Foundry sand
	- Waste soil from construction	- Steel slag
	- Incineration ash	- Waste white clay
Alternative heat energy	- Waste plastic	- Waste tire
	- Wood chips	- Coal mining waste
	- Waste oil	- Meat-and-bone meal
	- Recycled oil	
Admixture	- Blast furnace slag	
Additive	- By-product gypsum	

The transition of the specific amount of wastes for alternative raw materials is shown in Figure 5. The specific amount of wastes used as alternative raw materials has increased year by year. The maximum was 256.5(kg/t-cement) between 1990 and 2011. But, the range of

the specific amount of wastes used as alternative raw materials between 2008 and 2011 was 8.3(kg/t-cement). This shows that the use of wastes used as alternative raw materials is approaching the limit.

The transition of the specific amount of wastes used as alternative heat energy is shown in Figure 6. A tendency of increasing is found after 2008. This shows a possibility that the specific amount of wastes used as alternative heat energy will increase.

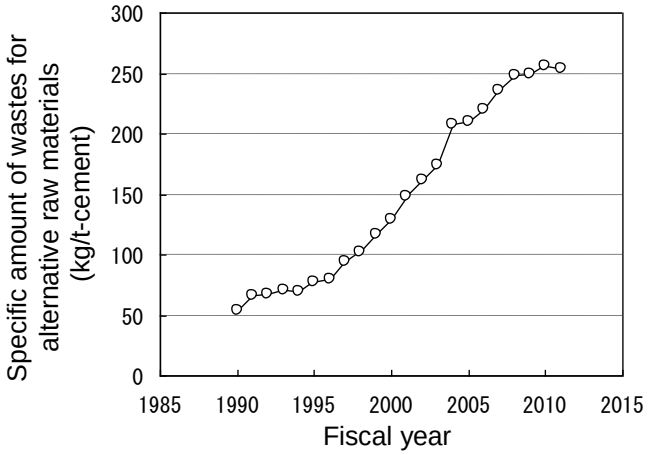


Figure 5 Transition of the specific amount of wastes used as alterative raw materials

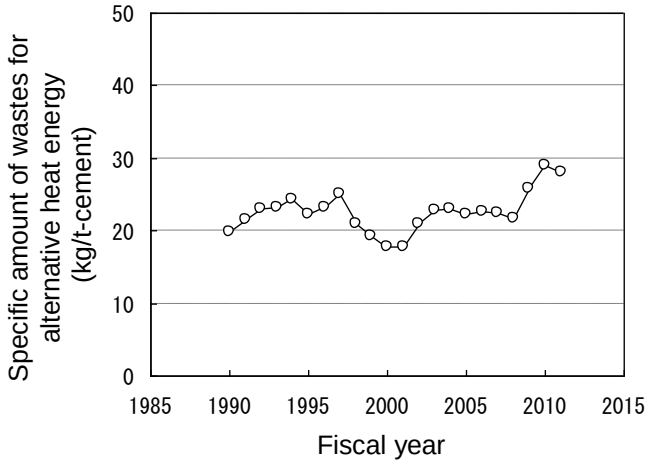


Figure 6 Transition of the specific amount of wastes used as alternative heat energy

APPROACH TO DECREASING NET SPECIFIC ENERGY OF CEMENT MANUFACTURING IN JAPAN

Voluntary Action Plan. The Japan Business Federation, called "Keidanren" in Japanese, has pushed the "Keidanren Voluntary Action Plan on the Environment". It calls "KVAP" in this paper.

"KVAP" deals with "Global warming" and "Waste disposal". All the cement companies in Japan have participated in "KVAP".

The target of cement industry of Japan on "Global warming" is as follows. And, in "KVAP", "Net energy for cement manufacturing" is defined as follows. It calls "NECM" in this paper.

< The target of cement industry >

The average of specific net energy for cement manufacturing for 5 years from Fiscal Year 2008 to 2012 will be reduced by 3.8 percent compared to specific net energy for cement manufacturing of Fiscal Year 1990.

-- Specific net energy for cement manufacturing --
FY1990 : 3,586MJ/t-cement
Target : 3,451MJ/t-cement

-- Definition of "Net energy for cement manufacturing"

"Net energy for cement manufacturing"
= "Heat energy for cement manufacturing(*)"
+ "Heat energy for private power generation(*)" + "Purchased power energy"

(*) The energy generated by use of wastes used as alternative heat energy is not included.

In "KVAP", the energy generated by use of wastes used as alternative heat energy is not counted. And, this is a common rule in "KVAP". In contrast, the "gross heat energy" includes the energy generated by use of wastes used as alternative heat energy in this paper (see Figure 3).

There are two major measures to reduce the energy for cement manufacturing. One is introductions of energy-saving devices or facilities, and the other is using of wastes for alternative heat energy.

Using of Wastes for Alternative Heat Energy. The transition of the rate of alternative heat energy to gross heat energy for cement manufacturing is shown in Figure 7. It increases year by year, and it reached 16.3% in 2010. This shows that the cement industry of Japan pushes positively the use of wastes used as heat energy for cement manufacturing.

The transition of the rate of alternative heat energy to heat energy for private power generation is shown in Figure 8. The rate of alternative heat energy to heat energy for power generation was 0.3% in 2004. But, it increases year by year, and it reached 9.5% in 2010.

This shows that the cement industry of Japan pushes positively the use of wastes for heat energy for private power generation as same as the heat energy for cement manufacturing.

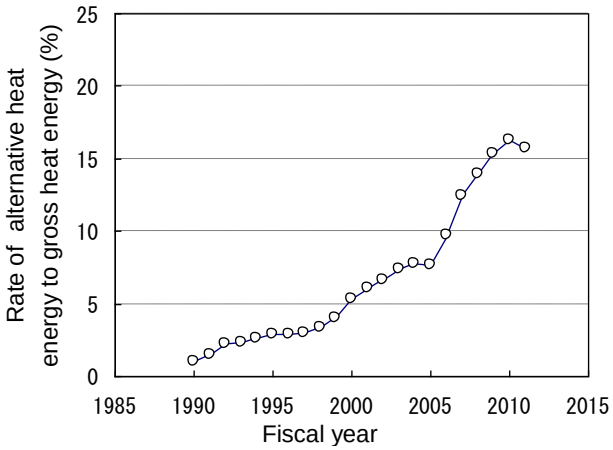


Figure 7 Transition of the rate of alternative heat energy to gross heat energy for cement manufacturing

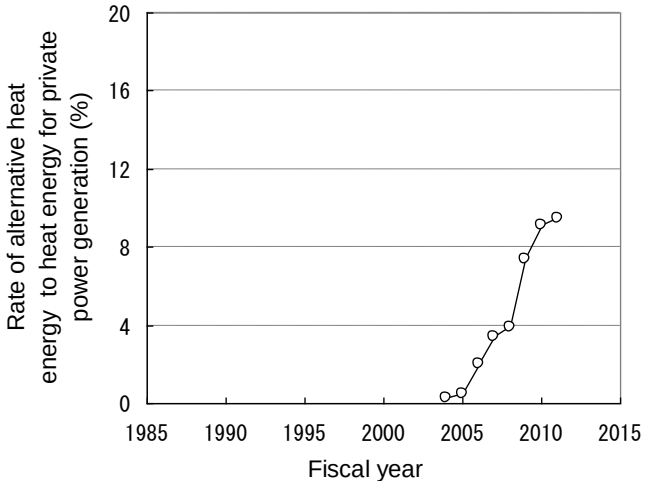


Figure 8 Transition of the rate of alternative heat energy to heat energy for private power generation

Transition of "NECM". The transition of the specific NECM is shown in Figure 9. The target of "KVAP" is that the average of specific NECM for 5 years from Fiscal Year 2008 to 2012 will be reduced by 3.8 percent compared to Fiscal Year 1990. The average of NECM in 4 years from Fiscal Year 2008 to 2011 is 3438(MJ/t-cement).

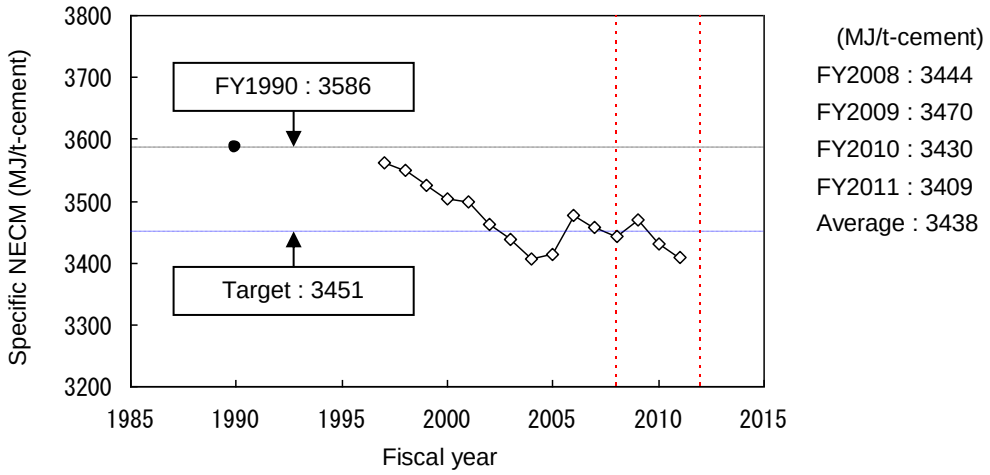


Figure 9 Transition of specific NECM

CO_2 EMISSIONS ON "KVAP"

In "KVAP", the CO_2 emission by burning of wastes as alternative heat energy is not counted. And, the CO_2 emission by decarbonation of lime stone in not counted, too. Then, the specific CO_2 emission by the production of cement is calculated based on these rules in this paper.

The transition of the specific CO_2 emission by the production of cement is shown in Figure 10. The range between 1997 and 2011 is 6.6(kg-CO_2/t-cement).

It is thought that the specific CO_2 emission by the production of the cement is affected by various kinds of factors shown below.

(1) Use of wastes
When wastes for alternative heat energy are used, the CO_2 emission by using wastes is not counted. It results the decrease of the CO_2 emission by heat energy for cement manufacturing and private power generation. On the other hand, the using wastes may cause the increase of electric energy by grinding the wastes. As a result of them, the specific CO_2 emission with the production of the cement may increase.

(2) Private power generation
Emission factor (kg-CO_2/kWh) for private power generation is usually higher than it for purchased power. But, the increase in the ratio of private power generation is expected in terms of energy security. So, the increase in the ratio of private power generation results the increase of the specific CO_2 emission for electrical energy.

(3) Emission factor (kg-CO_2/kWh) for purchased power
Emission factor (kg-CO_2/kWh) for purchased power varies depending on power generation mix of the power supplier.

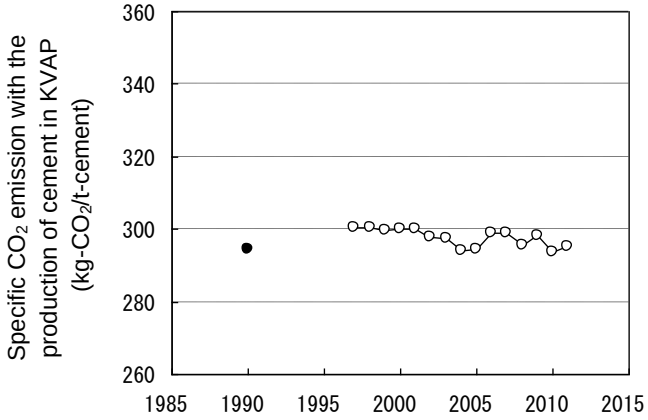


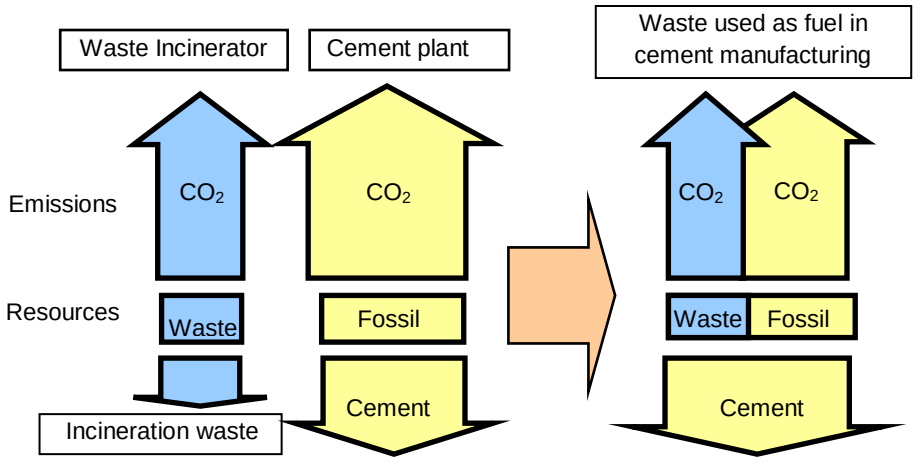
Figure 10 Transition of specific CO_2 emission with the production of cement in KVAP

CONSIDERATION OF USING WASTES ON "KVAP"

The energy generated by use of wastes for alternative heat energy is excluded in used energy on "KVAP".

The image of the use of wastes and CO_2 emission in cement plants is shown in Figure 11. If wastes are incinerated at waste incinerator which does not use heat energy by incinerating wastes, the heat energy is not used effectively. And, it is necessary to dispose the incineration ash.

But, if wastes are used at cement plant, the heat energy is used to product cement clinker or to generate power. Further, the ash of wastes is used as raw materials of cement clinker. Therefore the heat energy or CO_2 emission by using wastes in cement plants can be counted as zero.



NOTE: This image is partially modified from the original image that has been published in the reference [Cembureau].

Figure 11 Image of cement plant's contribution to CO_2 emission

CONCLUSIONS

(1) The specific gross heat energy increased little by little. But, the specific net heat energy decreased little by little. The main reason of these tends is the increase of the specific amount of used wastes.

(2) The range of the specific CO_2 emission by the production of the cement is between 1997 and 2011 is 6.6(kg-CO_2/t-cement). It is thought that the specific CO_2 emission by the production of the cement is affected by various kinds of factors.

(3) The specific amount of wastes for alternative raw materials has increased year by year. But, the range of it between 2008 and 2011 was 8.3(kg/t-cement). This shows that the use of wastes as alternative raw materials is approaching the limit.

(4) The rate of alternative heat energy to gross heat energy for cement manufacturing increases year by year. And, the rate of alternative heat energy to heat energy for power generation increases year by year, too. The cement industry of Japan pushes positively the use of wastes for heat energy.

REFERENCES

Cembureau(2009). “Sustainable Cement Production - Co-processing of alternative fuels and raw materials in the European cement industry, p.9
Japan Cement Association(1996). "Cement Handbook (1996)", p.22 (in Japanese)
Japan Cement Association(2001). "Cement Handbook (2001)", p.22 (in Japanese)
Japan Cement Association(2006). "Cement Handbook (2006)", p.6 (in Japanese)
Japan Cement Association(2012). "Cement Handbook (2012)", p.6 (in Japanese)
Japan Cement Association. http://www.jcassoc.or.jp/cement/1jpn/jg1h.html, (in Japanese)