Case Study on Energy Audit of Cement Plant

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ABSTRACT

Energy is one of the major inputs for the economic development of any country. However, the scenario of fossil fuel reserves does not agree with the ever increasing energy demands of a growing economy. Hence, it becomes highly necessary to undertake energy conservation efforts in order to ensure long term sustainability. Present paper discusses a case study wherein waster heat recovery has been utilized to save significant amount of energy in a cement manufacturing plant.

1. INTRODUCTION

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them. Coal and other fossil fuels, which have taken three million years to form, are likely to deplete soon. In the last two hundred years, we have consumed 60% of all resources as observed from Figure 1.

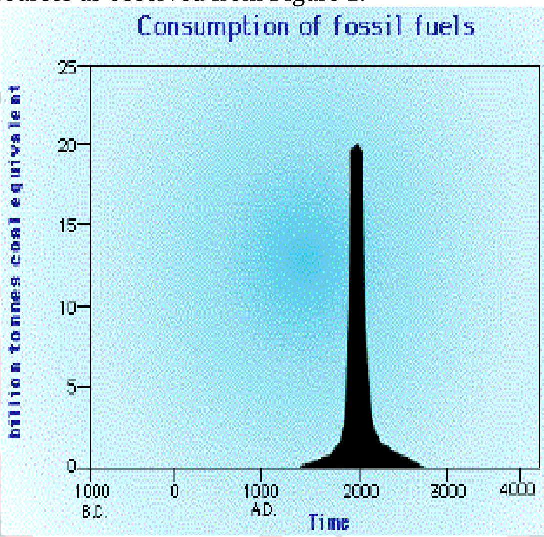

Figure1. 1: Consumption of Fossil Fuels over the years [1]

The usage of energy resources in industry leads to environmental damages by polluting the atmosphere. Few of examples of air pollution are sulphur dioxide (SO_2), nitrous oxide (NO_X) and carbon monoxide (CO) emissions from boilers and furnaces, chloro-fluro carbons (CFC) emissions from refrigerants use, etc. For sustainable development, we need to adopt energy efficiency measures.

Energy efficiency is defined as the ratio of energy required to perform a specific service to the amount of primary energy used for the process. Improving energy efficiency increases the productivity of basic energy sources by providing given services with less energy resources. Energy efficiency is achieved when energy intensity in a specific product, process or area of production or consumption is reduced without affecting output, consumption or comfort levels. Energy efficiency is often viewed as a resource option like coal, oil or natural gas. It provides additional economic value by preserving the resource base and reducing pollution. For example, replacing traditional light bulbs with Compact Fluorescent Lamps (CFLs) means one will use only 1/4th of the energy to light a room. Pollution levels also reduce by the same amount. Nature sets some basic limits on how efficiently energy can be used, but in most cases our products and manufacturing processes are still a long way from operating at this theoretical limit [1].

Objective

The objective of present paper is to demonstrate the savings obtained in energy through reduction of waste heat from a fluid stream going out of a cement plant. For the sake of confidentiality, only necessary technical details are mentioned here and name or other confidential details of the plant are omitted.

An energy audit of a cement plant was conducted to establish heat balance in a 5 stage Kiln. Flue gas analyzer and pitot tube was used to measure the following data at preheater outlet.

Temperature = 350^{o}C
Duct area = 3.098 m^2.
Static pressure = -435 mmWC
Dynamic pressure = 16.9 mmWC
CO_2 = 19.2%
Oxygen = 6%
CO = 0.06%
The atmospheric pressure is 10334 mmWC.

Atmospheric temperature = 20^{o}C.
Assume pitot tube constant = 0.85
Production rate of clinker = 55 TPH
Feed for kiln = 88.5 TPH
percentage of return dust in pH gas = 6.8 %
Coal cost = Rs. 6.95/- per kg.
Operating hours = 8000 per year.
Net calorific value of coal = 5,356 kCal.kg
Specific heat of PH gas = 0.25 kcal/kg ^{o}C,
Specific heat of return dust = 0.23 kcal/kg oC.

We need to calculate heat loss due to formation of CO, from preheater return dust as well as exit gas. Later on the preheater exit gas temperature was reduced to 330^{o}C as well as CO formation was avoided. This also helped in significant annual monetary saving, as explained in the following texts.

Preheater gas density at STP conditions
= (%O_2 x M_{O2})+ (%CO_2 x M_{CO2})+ (%(N_2+CO) x M_{CO})/(22.4 x 100)
= (6 x 32) + (19.2 x 44) + (74.74+0.06)x28/(22.4 x 1000)
= 1.398 kg/Nm^3

Gas density at given temperature and pressure
= STP Density x 273 x (10334+Pstatic)/((273+T)x10334)
= 1.393 x 273 x (10334 – 435)/((273+350)x10334)
= 0.587 kg/Nm^3

Preheater gas velocity calculation
= Pitot tube const x √(2 g Pd / density)
= 0.85 x √(2 x 9.81 x 16.9/0.585)
= 20.19 m/sec

Flow rate of preheater gas using continuity equation
= duct area x velocity
= 3.098 x 20.22
= 62.55 m^3/sec
= 62.55 x 3600 x 0.587 / 1.398
= 94550 Nm^3/hr

Thus, specific volume of preheater gas is obtained as
= 94550/55000
= 1.72 Nm^3/kg of clinker

Now we can calculate heat loss due to exit gas from preheater
= mass of gas x specific heat x temperature difference
= 1.72 x 1.398 x 0.25 x (350-20)
= 198.37 kCal/kg of clinker

Now we can calculate heat loss through return dust
= mass of dust x specific heat x temperature difference
= percentage of return dust/100 x clinker factor x specific heat x temperature difference
= (6.8/100) x (88.5/55) x 0.23 x (350 – 20)
= 8.3 kCal/kg of clinker

Now we can calculate heat loss through formation of CO in the process
= mass of CO x 67636
= specific volume of preheater gas x %CO/(22.4 x 1000) x 67636
= 1.72 x 0.06/(22.4 x 1000) x 67636
= 3.12 kCal/kg of clinker

Afterwards, exit temperature of preheat exit gas was proposed to be reduced to 330^{o}C. in this scenario, the corresponding heat losses have been estimated as follows. Also, the case of avoiding the formation of CO was taken into account.

Now we can calculate heat loss due to exit gas from preheater
= mass of gas x specific heat x temperature difference
= 1.72 x 1.398 x 0.25 x (330-20)
= 186.35 kCal/kg of clinker

Saving in heat loss for this condition = 197.95 – 186.35 = 12.02 kCal/kg of clinker

Now we can calculate heat loss through return dust
= mass of dust x specific heat x temperature difference
= percentage of return dust/100 x clinker factor x specific heat x temperature difference
= (6.8/100) x (88.5/55) x 0.23 x (330 – 20)
= 7.8 kCal/kg of clinker

Saving in heat loss for this condition = 8.3 – 7.8 = 0.5 kCal/kg of clinker

Hence, total saving in thermal energy = 12.02 + 0.5 + 3.12 = 15.64 kCal/kg of clinker

Because of this, the saving in coal obtained = 15.64 /5356 = 0.00292 kg/ kg of clinker

Saving obtained in coal on annual basis

= 0.0029 x 55 TPH x 8000 hours/year

= 1276×10^3 kg/year

= 1276 ton per year

= $1276 \times 10^3 \times 6.950$

= Rs. 88,68,200/- per year

CONCLUSION

It was observed that recovering the substantial amount of energy from waste exhaust stream can result in significant amount of saving. Such a energy saving is beneficial to the company as well as to the environment. More importantly, energy audit is a systematic approach towards achieving energy conservation.

REFERENCES

[1]. Guide books for Energy Auditor's Certification Examination by BEE, New Delhi.