Power and Other Energy Utilities From Low Grade Waste Heat – Novel Technologies to Reduce Carbon Footprint

Subha Mondal, Aliah University, Kolkata, India
Sudipta De, Jadavpur University, Kolkata, India

Nomenclature

c_p Specific heat at constant pressure (kJ/kg K)
e_g Exergy of flue gas (kJ/kg)
T_0 Ambient temperature (K)
T_g Flue gas temperature (K)

Introduction

The rise of global average temperature due to excessive emission of greenhouse gases (specifically CO_2) due to combustion of fossil fuel is an issue of great concern for the survival of future generation. Fossil fuel based power plants are responsible for the majority of this CO_2 emission. However, fossil fuel burning is unavoidable for a considerable period to maintain a desirable industrial growth and living standard.

Though renewable power generation is increasing worldwide, the majority of the global demand for electricity is still from coal based power plants. There is a major gap between generations of secondary energy using renewable resources and corresponding global demand for a sustainable development. In this situation, replacement of older coal based power plants with an improved natural gas based power plants, retrofitting of existing low efficient power plant, incorporating CO_2 capture and sequestrations are possible options to continue with fossil fuel and simultaneously to fight against the threat of global warming. However, all of these are long term and capital intensive options.

On the other hand, a large part of all industrial energy inputs through combustion of fuels is finally released to the local atmosphere as waste heat for existing technologies. This waste heat may be utilized to produce more electricity introducing suitable technology for this purpose. Thus, the amount of fossil fuel burning required for generating an equal amount of power will be reduced and corresponding CO_2 production will be eliminated due to adoption of these waste heat recovery schemes.

It is observed in the literature that if waste heat is available above 250°C, steam based Rankine cycle is the well established technology for converting waste heat into secondary energy. Steam based CCGT (Combined Cycle Gas Turbine) may be cited as an example in this respect. However; innovation is required to generate secondary energy from waste heat available below 250°C.

Some of the refrigeration cycles are heat driven. Replacement of vapour compression refrigeration system with such low grade waste heat driven refrigeration systems will also lead to lesser fossil fuel consumption. Ejector based refrigeration cycles are capable of producing refrigeration effects using low grade waste heat even when waste heat temperature is as low as 100°C.

Due to over use and even with climate change available water for human consumption is fast decreasing. Desalination technology is an important need for future sustainability. Low grade waste heat may also be utilized for the purpose of desalination adding more sustainability. In the middle-east countries, substantial amount of drinking water is produced by the process of desalination.

Review of Energy Scenario Worldwide and Share of Fossil Fuel

Global energy consumption is ever increasing. It is reported in International energy outlook IEO (2017) that between 2015 and 2040 world energy consumption will increase by 28%. More than half of this increment in energy consumption will be in non-OECD Asia (including India and China) due to the rapid economic growth of these countries. It is predicted in this report that there will be 51% increment in energy demand in non-OECD Asia. In Africa and Middle East, this growth will be 51% and 45% respectively. Industrial sector that consumes more than 50% of the world energy production appears to be a major end user of global energy supply.

Though, global contributions of renewable energy are increasing sharply, fossil fuels like liquid fuel (including petroleum), coal and natural gas are the major sources that still contribute to most of the global energy demand. World energy council/ resources, 2016 summary (2016) that oil accounts for 32.9% of global energy demand. On the other hand, coal accounts for close to 30% of global basic energy consumption. 40% of the global secondary energy demand is by coal based power plants. Natural gas is the third major contributor to global primary and secondary energy demands. Presently it contributes to 24% of the global primary energy demand and 22% of the global electricity demand.