

Development and Perspective of Waste Heat Recovery Technology

Qixing Huang*

Shanghai Weiyu high school, Shanghai, China

*Corresponding author: ylyl@jedzw.com

Abstract. Rapid industrial development and evaluation has triggered enormous energy and environmental issues, of which the fast depletion of energy has been one of society's main concerns. The scarcity of energy is one of the most important environmental issues that international bodies urge to tackle. Scientists coming from different academic groups collaborate to find out high-efficient, low-emission manufacturing devices to deal with the scarcity. People have been already familiar with some methods that people used to take nonrenewable resources, coal, oil, and so forth, in place of solar energy. In this paper, another novel perspective that increases the quantity of usable energy after the industrial process finishing will be introduced, the waste heat energy. As a promising but little-exploited technology, I will briefly cite the present stage of investigation and evaluation. Hopefully, this paper can spark any interest or idea the researchers have to engage in improving the waste of heat energy.

Keywords: Waste heat recovery, Waste heat resources, Waste heat recovery techniques.

1. Introduction

As technology is keeping development, the human demand for energy will grow at an amazing rate. Recently, some scientists predicted that the quantity of demanded energy will grow five times by 2100. Unfortunately, people have not explored and mastered renewable sources efficiently. In that case, the extremely high demand for biomass, fossil, and coal which is non-renewable will quickly deplete the left energetic storage. For instance, Bangladesh, which is the 9th largest country in the world, has the lowest energy consumption in decades. However, as the countries are experiencing revolutionary progress in industrialization and urbanization, the trend of increase in energy consumption is obvious enough. It happens all around the world. Moreover, the problem has already extended from the developing country to the developed country. Hence, machines or techniques are necessary to help reduce the large-scale energy consumption produced by fossil fuels. Nowadays, people are striving toward better energy sources and alternative ways to consume energy. Recently, more and more scientists engaging in the aspect of output energy. If we can recover the energy which is not fully used after it was processed. The novel and promising technology, waste heat recovery, which can in part alleviate the surplus of energy, will be introduced in this paper. Basically, the waste heat energy is working for transferring the output of energy at high temperature into reversely plant field and for other purposes. The present level of innovation has developed a variety of waste heat resources systems which are judged by their sources. In the following paper, attention will be paid to the present experimental progress of waste heat energy in detail. Moreover, as an immature developing device, evaluation should be important.

2. Source of Waste Heat

Before introducing the method for tackling energy scarcity, different aspects which involve waste heat generation will be discussed firstly, in order to conduct a more efficient study on heat recovery systems should have known well about what aspects we can inspect and investigate so that it will be more efficient.

2.1. Industry Resources

First is the industry energy loss. For instance, the textile industry is one of the biggest and most productive industrial companies in the world. In India, textile production contributes to 17% of gross domestic product over the world and offers thousands of people jobs to save them from poverty. Although each group of processes in textile is not as energy-intensive as it should have consumed. However, it consists of so many complex and energy-used patterns which ultimately pose a large amount of energy use Figure1. According to the statistic, the conversion efficiency of textiles, the most innovative and highly-investment in the U.S, only can reach 85% at maxima [1]. It means that 15% of energy will be lost during the process. (Lost means that the energy is not transferred into practical use). It will not only pose a large amount of investment wasted but also give rise to higher energy used. The American data suggest that 36% of the total input of energy will be lost during the textile process [1].

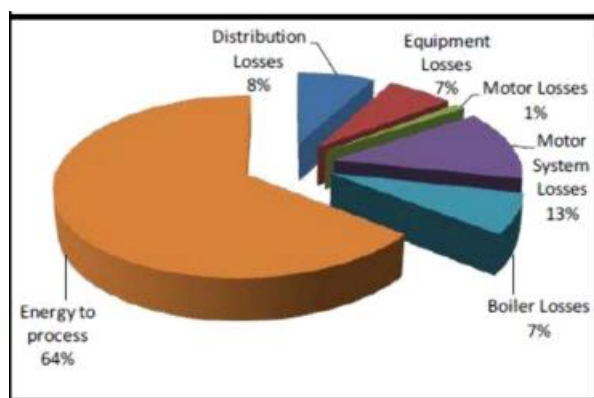


Fig 1 Onsite energy loss of each process in U.S textile

2.2. Urban Sources

The household will produce sufficient waste heat from the thermal system. For instance, the thermal heater which is possessed almost by every family will produce a lot of waste heat during the process of transferring the electric energy into thermal energy. Moreover, the daily sewage water produced will have a relatively higher temperature than the air environment but also have a higher flow rate. It provided a potential source for the recovery system [2].

Also, the development of transportation leads to immense growth in energy demand. According to the experiment, 30 percent of the energy all plant field produce is consumed by the vehicles' operation. However, about one-third of energy input is lost in dealing with the friction in metal or other. For instance, the internal combustion engine (ICE) which is operated by the fuel only makes 21% of the input energy [3].

3. Advantages of Waste Heat Recovery System

WHR system could improve energy efficiency to achieve eco-friendly industrial production. The European Union consumed a total of 3280 TWh in 2018, among which Germany consumed 711 TWh, France consumed 342 TWh, and Italy consumed 304 TWh. According to the estimation proposed by the leaders of the EU in waste heat energy, if the provision of a waste heat system is successfully settled over the EU, the waste in the thermal energy in the EU was calculated to be around 920 TWh. Much lower than the present demand level of energy.

In addition, the WHR system also has characteristics of environmentally friendly. The global energy demand increased by 2.18% and the statistics reveal that this number will continue to soar for lasting 30 years. As mentioned in the following text, an organic rankine cycle (ORC) waste heat recovery system is invented to compensate for part of the energy quantity from other limited resources. However, in the past research of ORC, R123a, one of the types of fluid used in the system, are proved that will indirectly pose global warming and the destruction of the ozone layer. Hence, increasing

demand for mitigating the greenhouse effect encourage scientist to invent a more environmental-friendly fluid type. Fortunately, the R1234ys system manages to operate in the system and has the most potential performance to lower carbon emissions [4].

In the present stage, waste heat recovery still has a long way to develop to be officially and extensively applied to use. But, luckily, scientists have already been aware of the significance of ORC. According to recent years, 77% of numerous papers are dedicated to improving the performance of ORC. For instance, the novelty of RORC has a thermal efficiency of 7.98%, which is 1.38% higher than the ORC [5].

Firstly, fierce market competition exists in the development of WHR systems. How much energy is transferred into commercial use has a direct relationship with cost. A waste heat recovery system is able to provide more energy sources to use and less carbon emission can help them deal with the pollution permit tax. In the economic aspect, this kind of innovation of technology is likely to prompt long-term economic growth. Hence, if the waste heat recovery achieves the balance of cost and benefit, companies will have enough incentive to adopt the system in order to increase their compactivity.

4. Typical types of the WHR system

In the present stage, there is a variety of systems invented to deal with waste heat recovery. In order to figure out which WHR system is the most suitable one, research and calculation regarding the amount and grade of waste heat are necessary.

Before jumping into the introduction of a WHR system, how to store the waste heat and efficiently transfer it into the input energy need to be considered. The regenerative, which base on the property of heat capacity. The system works by capturing the combustion air exhaust gas and forcing them to pass through the alumina ball heat media, with the yellow lines in Figure 2. In that case, the heat can be stored by the media in the heat exchangers, but it may not be permanent storage as it is likely to leak out into the air. Hence, after garnering enough heat, the valves of the system will open, in order to make the media have full contact with the fresh oxygen which is regarded as the three essential ingredients that give rise to the firing [6]. So that combustion air, produced by the flaming fire, will follow with the red arrows and blue arrows and back to the original position. Hence, by forming recycling, the waste heat energy can be stored.

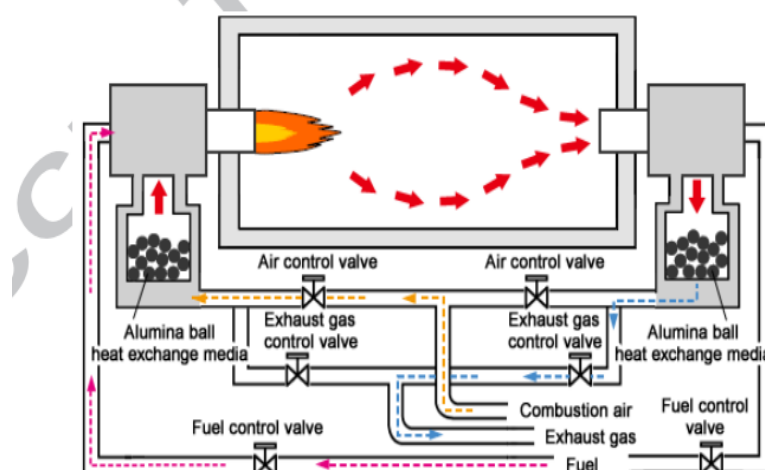


Fig 2. Schematic diagram of heat regenerative process [7]

Nowadays, people have already paid a lot of attention to the low-grade heat energy used such as solar energy and ORC waste heat energy system. The ORC system mainly works by collecting the heat energy into the organic working medium. In the process, the device keeps absorbing the heat energy. Reaching a certain value of pressure and temperature, the device will release the pressurized steam to activate the turbines. So that the heat energy can be diverted into electrical energy. In

particular, an isobaric heating process in boiler and superheater, in which isobaric preheating of unsaturated water into saturated water. And then iso-pressure isothermal vaporization into saturated steam. Then isobaric heating into superheated steam. The adiabatic expansion process of superheated steam in the steam turbine, and the working medium works externally. isobaric exothermic condensation process in the condenser. adiabatic compression process of water in the feed pump.

4.1. Run around coil (RAC) system

RAC system consists of a pair of coil pipes, with a type of fluid-filled. The fluid in the coil can carry the waste heat energy which is captured by the recuperator and taken into the secondary recuperator, where it would be mixed with the supply air. The exchanging of the heat is achieved by using the liquid round coil which is located in the middle of the system [5]. The RAC system is shown in Figure 3.

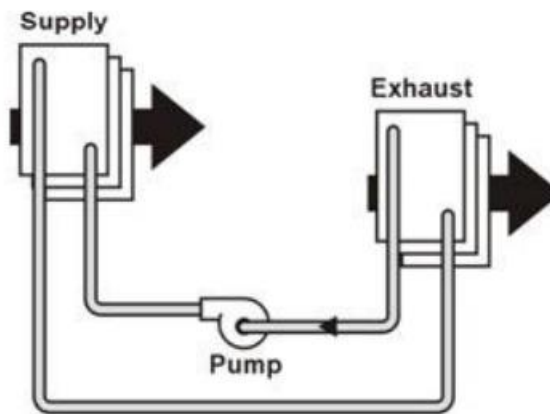


Fig 3. RAC system working process [8]

4.2. Heat recovery steam generators

HRSG system is one of the most complicated waste heat recovery systems which can improve the efficiency of diverting energy by utilizing the waste heat in industries.

Basically, the HRSG system consists of triple parts (Figure 4). As the feedwater enters the systems from the inlet valves and is guided to the evaporator, the middle of the system, by the economizer. Processed by the evaporator, the feedwater will change into steam as the increasing temperature reaches the saturation level and continue to move to the steam drum and superheater. As the industrial waste gas with high temperature flows in at the same time, the water steam will be offered with sufficient heat energy. Finally, the gas state will be separated into two different locations by the combination of gravity and mechanical modification. Hence, it largely improves the efficiency of waste heat energy.

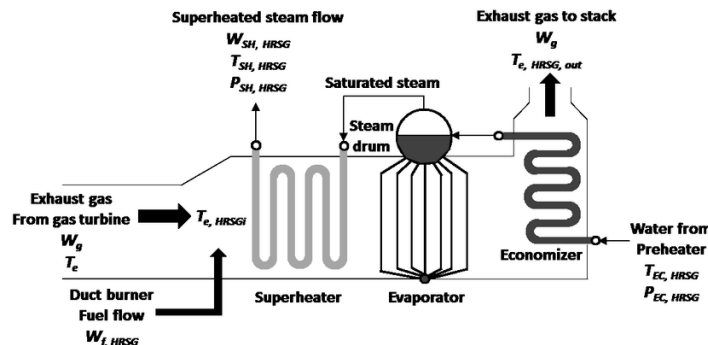


Fig 4. HRSG system working principle diagram [9]

4.3. Flat heat pipes(FHP) system

Compared with its former system Heat pipes (HP), it also can be applied to various situations such as nuclear and LT applications. Also, for applications such as biotechnology, medical and chemical industrial application, and pharmaceutical which usually involves low temperature, the HP system is especially effective.

Moreover, FHP now has some extra benefits due to its special reformed frame. For instance, the combination of photovoltaic thermal cells and flat pipes will largely reduce the cost of maintenance and feasibility. According to the data of FHP, the potential thermal efficiency can reach 75% at max (depending especially on the temperature of sources or the established size of FHP. Theoretically, larger size and larger efficiency.), It can save for 70000 KWh [10].

4.4. Trilateral flush cycle(TFC)

Although the ORC (organic rankie cycle) can be commercially used and adopted with a low-temperature interval, the high-grade waste heat that is typical of Aluminium has not been fully developed by the ORC. Hence, based on the system investigated recently, TRC can provide a comparative advantage in contrast to ORC. It is the opposite of another system. The thermodynamic cycle is beginning in the saturated state instead of the vapor state. Relatively, TRC's recovery potential is double of the ORC system. Hence, the extra cooling tower is not required for officially operating [11].

5. Conclusion

The waste heat recycles and reused has turned out to be an effective way of achieving high-efficiency energy conversion and energy use. According to the research in this paper, industrial waste heat such as the flue gas waste heat, cooling medium waste heat, wastewater waste heat, chemical reaction waste heat, and household waste heat could be important resources in the waste heat recycling system. Despite policies that have been implemented to promote the recycle waste heat and advancement of the waste heat recycling technology, further research is still necessary on the recovery and utilization of LT waste heat. Although this waste heat grade is very low, the quantity is large, its recycling is beneficial for further energy-saving and eco-friendly goals.

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