Feasibility Analysis and Parametric Design for Waste Heat Recovery of Cement Plant

Sajjad Hussain[1], Dr. Riffat Asim Pasha[2]
[1]Department of Mechanical Engineering
University of Engineering and Technology Taxila
sajjadhussain334@gmail.com

[2]Department of Mechanical Engineering,
University of Engineering and Technology Taxila
asim.pasha@uettaxila.edu.pk

ABSTRACT

The cement industry is the most emerging industry in Asian countries. In the cement manufacturing process, a large amount of hot gases carrying a high amount of heat depending upon the production capacity of a plant is exhausted. This heat can be utilized for power generation using waste heat recovery processes. In existing systems, no software tool is used to check the feasibility and possible power output for a cement plant. This paper represents the waste heat recovery unit operation modeling using Aspen Hysis Software. Aspen Hysis Software is used as an industrial design software tool to investigate the feasibility of WHRP. The data of three plants was used in design Aspen Hysis Software for designing the waste heat recovery power plant. Waste heat from cooler and kiln was used for generation of steam in boilers. The main parameters of a waste heat recovery plant i.e Cooler, Boilers, Mixer,Turbine, Generator, Compressor and pump were modeled on the Aspen Hysis Software. Similarly, the process has been drawn on software as per flow of hot gases/steam. The result shows that usage of the Aspen Hysis model provides the optimal heat recovery and optimal power that can be achieved depending on the basic values as per capacity of the plant. **Keywords**: WHRP, Aspen Hysis, Cement Plant

1. INTRODUCTION:

The specific average energy consumption is estimated as 100 to 150 equivalent kg of oil per produced ton of cement, and the energy cost may reach 40 to 60% of the total production cost Amiri, A [1]. Engineers have done intensive research work in taking a systematic approach to defining and implementing waste heat recovery projects for industrial, commercial, and institutional facilities where these opportunities exist Kazmi, S. A [5]. Recovery and reuse of this heat has the potential for significant reduction of energy costs and improving profitability Απέργη, [2]. A considerable quantity of heat is wasted in the atmosphere during normal operations of cement manufacturing. This waste heat can be utilized to generate electrical power. Boilers are used to generate steam by using the extra heat available from the kiln pre-heater and cooler Sathiyamoorthy [3]. Steam from the boiler runs the turbine and generator to produce the electrical power. Aspen Hysis is a designing tool used for designing industrial equipment and processes Bayuaji [4]. In this study, Aspen Hysis software is used for modeling of the main parameters of WHRPP. The proposed/average values of data were used in the software and the final power was obtained accordingly. All the parameters have been drawn on the software and the input values are used to get the output result. All parameters and their output results are described shortly.

2. Kiln/Cooler

The input hot gases are taken from the Kiln which are used for steam generation in boiler. Figure 2.1 describes the input/output parameters of the kiln.

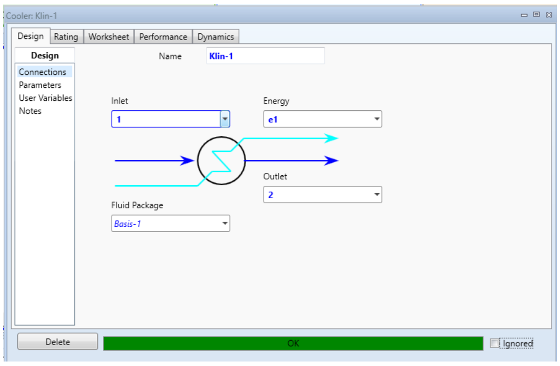


Figure 2.1: Kiln input/output parameter

Here the temperature is 455 ℃, the pressure is 0.1 MPA, and mass flow rate is 7966kgmol/hr. e1 is the output energy, which comes out to be 23.70MW. In Aspen Hysis software, WHRP is designed for a cement plant having two production lines. Kiln-2 on the second production line has identical parameters. The relationship between input temperature (Kiln exhaust) and output energy is described in figure 2.2.

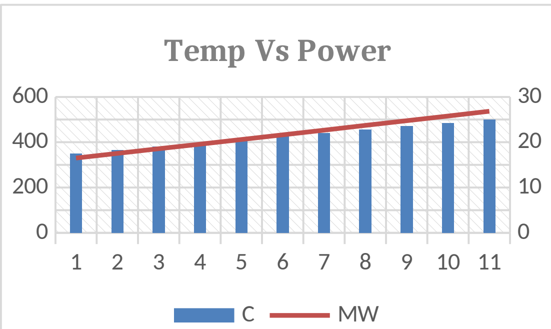


Figure 2.2: Kiln Temperature and output energy.

3. AQC Boilers

The boiler is used as a heat exchanger for generation of steam. Input feed water with an input temperature of 41.86 ℃ is converted to steam at a temperature of 354 ℃. A phase change process takes place. Input and output values calculated through Aspen Hysis are given in Fig 3.1.

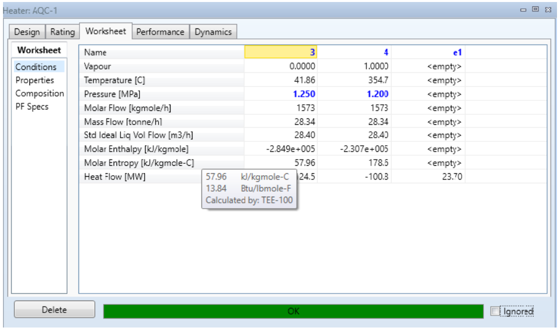
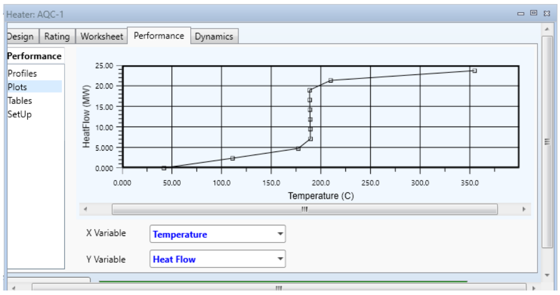


Figure 3.1: Inlet/outlet values of Boiler

The Performance chart in Aspen Hysis describes the relationship between different parameters. The change in temperature and heat flow are descried in Figure 3.2.



The input and output parameters are identical for similar capacity production lines. Power output in the form of heat flow is given as e1 which comes out to be 23.70 MW. Two boilers for production line 1 & 2 are identical with similar capacity. Table 3.1 describes the temperature and pressure values.

Sr. No.	Parameters	Values
1	Inlet Temperature (℃)	41.86
2	Inlet Pressure (MPa)	1.250
3	Outlet Pressure (MPa)	1.200
3	Mass flow rate (Ton/hr)	28.34
4	Outlet Temperature (℃)	354
5	Delta P (kpa)	50
6	Delta T (℃)	312.9

Table: 3.1: Temp/Pressure Values

4. Mixer

The Mixer used in Aspen Hysis software works for mixing of both steams from boilers AQC1 & AQC2. The output steam from **AQC1** is termed as **4** and from **AQC2** is termed as **44.** Basic connections are given in figure 4.1.

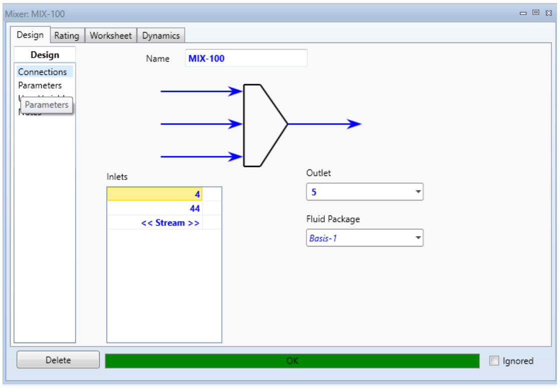


Fig 4.1: Basic connections of mixer

5. Pipes/Fitting Losses

This portion deals with the losses that occur within the pipes and fitting along with other losses. It can be seen that in each unit the same amount of heat or energy is lost during the transmission through pipes and other sources. In the WHRP system designed on Aspen Hysis the losses are figure out as approx. 0.4678 MW.

6. Turbine/Power Production:

This portion describes the main parameters of the WHRPP system. Steam from the mixer is injected into the turbine. In Aspen Hysis System, the Expander has been used as a Steam Turbine. The change in different values after passing through the turbine is given in worksheet at figure 6.1.

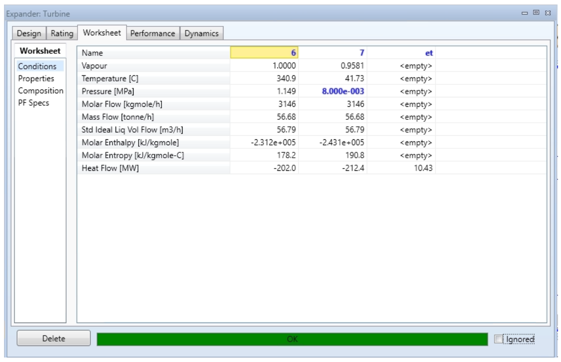


Figure 6.1: worksheet on Turbine

In Aspen Hysis System, the Expander has been used as a Steam Turbine

Changes in different parameters after passing through the turbine can be seen on the worksheet. The waste heat recovery systems used in cement plants operate on Rankine Cycle SHANDILYA, K. [6]. The vapour fraction changes from 0 to 0.9581. Similarly, the temperature drops from 340.9 °C to 41.73 °C. A clear change has been observed. Pressure drops from 1149kpa to 8kpa. Mass flow and ideal liquid volume flow remain the same. Molar entropy changes from 178.2 to 190.8KJ/kgmole-c. Power obtained is in the form of heat flow termed as MW, which is 10.43 MW. Performance parameters of the turbine in Aspen Hysis are given in figure 6.2 & 6.3.

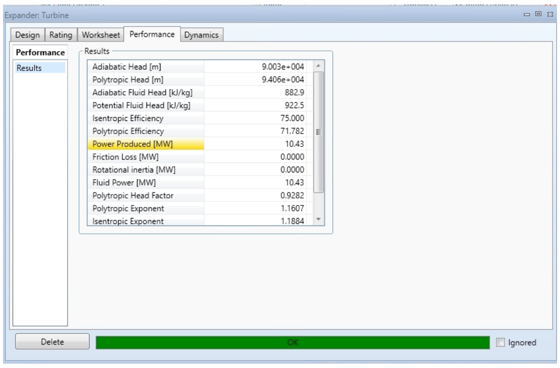


Figure 6.2: Performance parameters of turbine

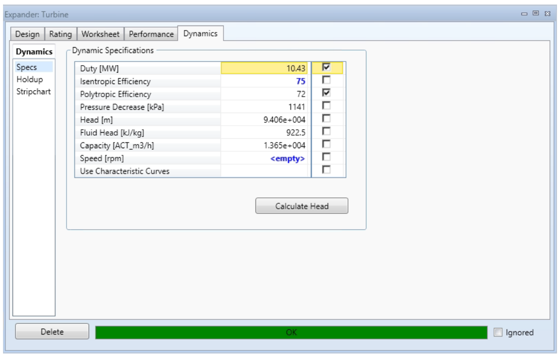


Figure 6.3: Performance parameters of turbine

7. Conclusions:

All parameters were incorporated into the design of WHRP in Aspen Hysis software. The waste heat is to be utilized for power production and energy saving. This research helps us in designing a waste heat recovery power plant in a cement plant. Results show that with the change in capacity of units, heat content being received for boiler changes and, accordingly, all the parameters change. Hence, by putting the initial values of main parameters in the software, it provides the final result against those values. The flow diagram of a WHRP on Aspen Hysis software is given in figure 7.1.

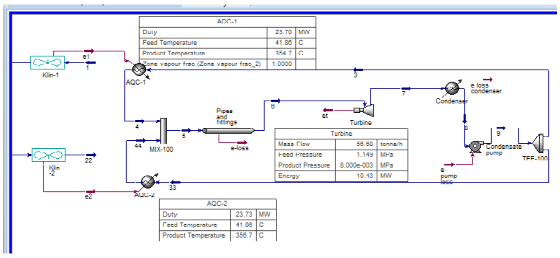


Figure 7.1: WHRPP on Aspen Hysis flow diagram

This design helps the cement industries to make a decision and check the output power that can be obtained from waste heat recovery plants. The results show that for a production unit of capacity 3750 TPD, the power that is extracted is approximately 10MW as per design made on Aspen Hysis. This estimated power does include the power to run the equipment and accessories of the power plant itself.

References:

[1] Amiri, A., & Vaseghi, M. R. (2014). Waste heat recovery power generation systems for cement production process. IEEE Transactions on Industry Applications, 51(1), 13-19.

[2] Απέργη, Π. (2012). Power generation from waste heat in cement plants: application in Lafarge Volos plant (Master's thesis).

[3] Sathiyamoorthy, M., & Biglari, M. (2016). A case study: the waste heat recovery and utilization for power generation in a cement plant (phase-1). Adv. Res. IT Eng, 5, 1-26.

[4] Bayuaji, R., Biyanto, T. R., & Irawan, S. (2015, September). Design of cement plant waste heat recovery generation. In 2015 Australasian Universities Power Engineering Conference (AUPEC) (pp. 1-5). IEEE.

[5] Kazmi, S. A. A., & Khan, M. Z. (2012, October). Power generation by different waste heat recovery methodologies with reference to cement works in Pakistan: A case study for cement industry in Pakistan. In *2012 International Conference on Emerging Technologies* (pp. 1-6). IEEE.

[6] SHANDILYA, K., KUMAR, R., & PANWAR, A. POWER GENERATION FROM WASTE HEAT EXTRACTED THROUGH CLINKER PRODUCTION IN CEMENT INDUSTRY.

[7] Priyadarshini, S. N., & Sivakumar, D. B. (2014). Waste heat recovery in cement plant. International Journal of Engineering Research & Technology, 3.