Design model for pre cooler

3-1 Introduction

3-1-1 Environment description

Garri power station is located 70 km north of Khartoum. The station consists of eight gas turbines. Four of them (located in Garri 1) are of type PG6581(58khp design power), which are equipped with heat recovery and connected to two steam turbines as combined cycles (Figure 3-1). Three of the other four turbines (located in Garri 2) are type PG6551 (55khp design power), which were commissioned in 2003 and used to work as open cycles. In 2007, a fourth gas turbine, type PG6581 was added together with two steam turbines to Garri 2 block so as to become similar to Garri 1

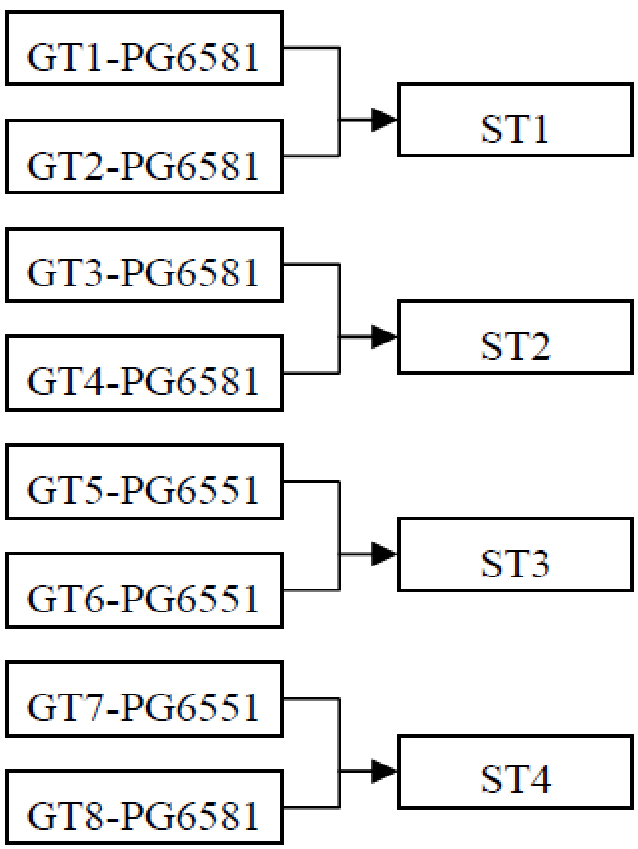

Figure 3-1 Layout of Garri (1&2) power plant

The climate of the area is the semi desert climate influenced by the north-south movement of dry northerly winds and moist southerly winds that produce a wet summer and a dry winter. Figure 3.2shows the average maximum and minimum daily temperature and rainfall .Due to the high ambient temperature, there is a drop of 10 MW in each turbine of type PG6581 and 8 MW in each turbine of type PG6551. The total loss of power is 74MW in the eight gas turbines. This waste power could be recovered to the national grid, which suffers from power shortage. From Figure 3.2, there is a potential to reduce the inlet air temperature to 15 °C for the gas turbines at Garri power station [12] O.H.M. El-Hassan et al.

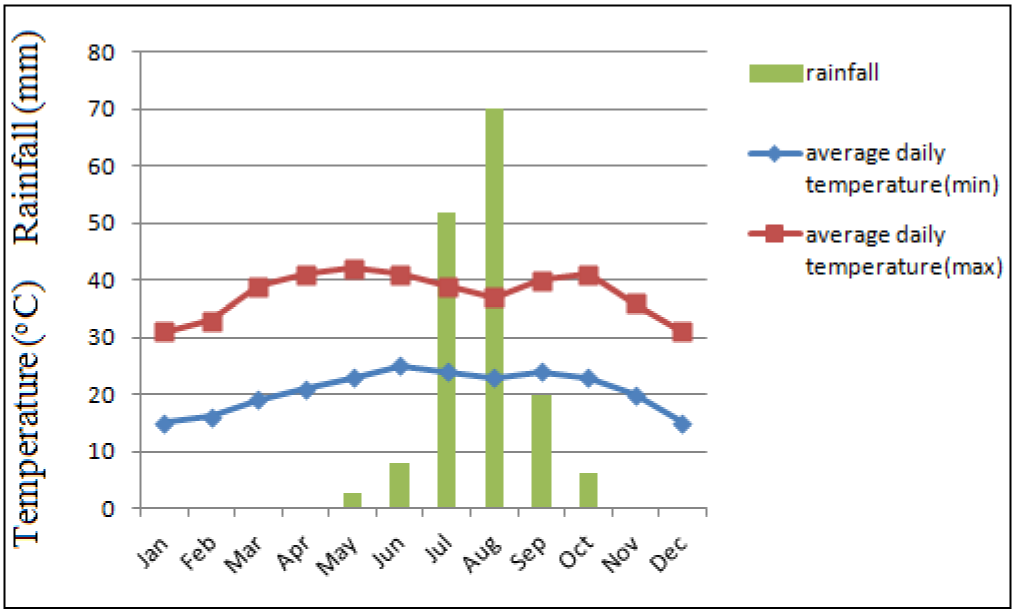

Figure 3-2 Climatical data of Garri[12].

3-1-2 Water Availability at Garri

The coolers used the service water available in the plant which is taken from the Nile and treated in the pretreatment plant of the power station. The pretreatment system consists of pre settler, clarifier, pumps and piping to transfer the water to the power stations. Mainly aluminum poly chloride is used to remove the mud and sodium hy poclorideis is used for the removal of algy. The water specification is shown on Table 3.1.

Table 3.1 Specifications of Garri service water [12]

No	Test	Unit	Value
1	PH	-	7.8
2	Conductivity	μs/cm	200
3	Total Hardness	ppm	70
4	Calcium Hardness	ppm	30
5	Chloride	ppm	5.2
6	TDS	ppm	110
7	Alkalinity	ppm	76
8	Silica	ppm	8.6
9	Iron	ppm	-
10	TSS	ppm	<1

3-1-3 Chilling system

A chilling system for gas turbine inlet air is a beneficial option for installations where high ambient temperatures are common. a chilling coil is inserted in the filter house downstream of the filtering elements, in the clean air path. Downstream from the coils, a mist eliminator is installed in order to prevent condensed water droplets from entering the gas turbine inlet duct. The chiller coil cooling fluid is usually a mixture of water and glycol to avoid freezing in the coil tubes. the economic benefit of chilling system is directly related to the potential average increase in annual output, and this in turn is dependent on average ambient conditions. A chilling system can be installed on any gas turbine.

In a chilling system, heat is removed from the inlet airflow by means of heat exchangers chilling coils.

- ❖ Chilling module consisting of:
  - • Heat exchangers.

• Mist eliminator.
• Drain system.

3-2 Design Suggested procedures for pre cooling model

This developed pre cooler system depicted in figure 3-3 consists of main three components:

- Chiller system
- Cooling tower
- Heat exchange

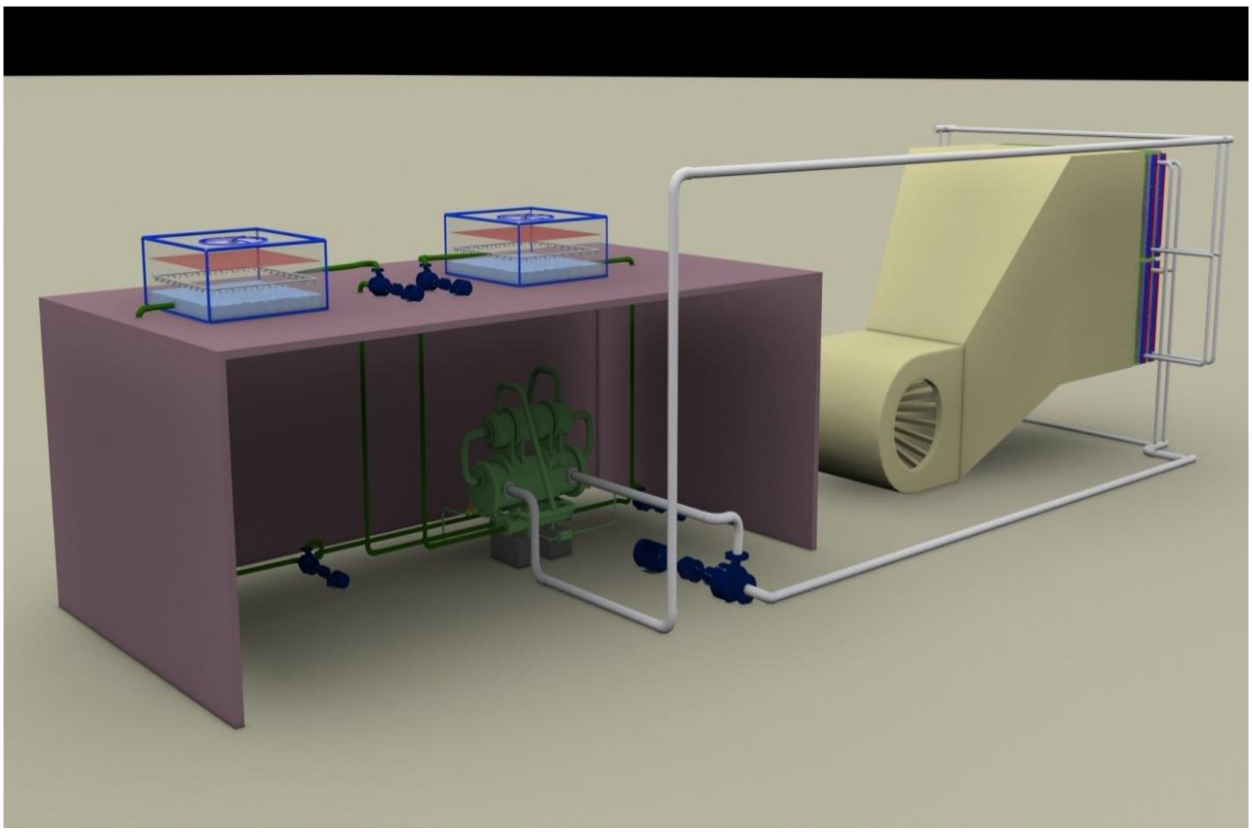

Figure 3-3 Main components of the pre cooler system.

The detail description for each component in the pre cooler system shown below:

3-2-1 Chiller system

Use a vapor-compression refrigerant cycle to cool a fluid shown in figure3.4 below

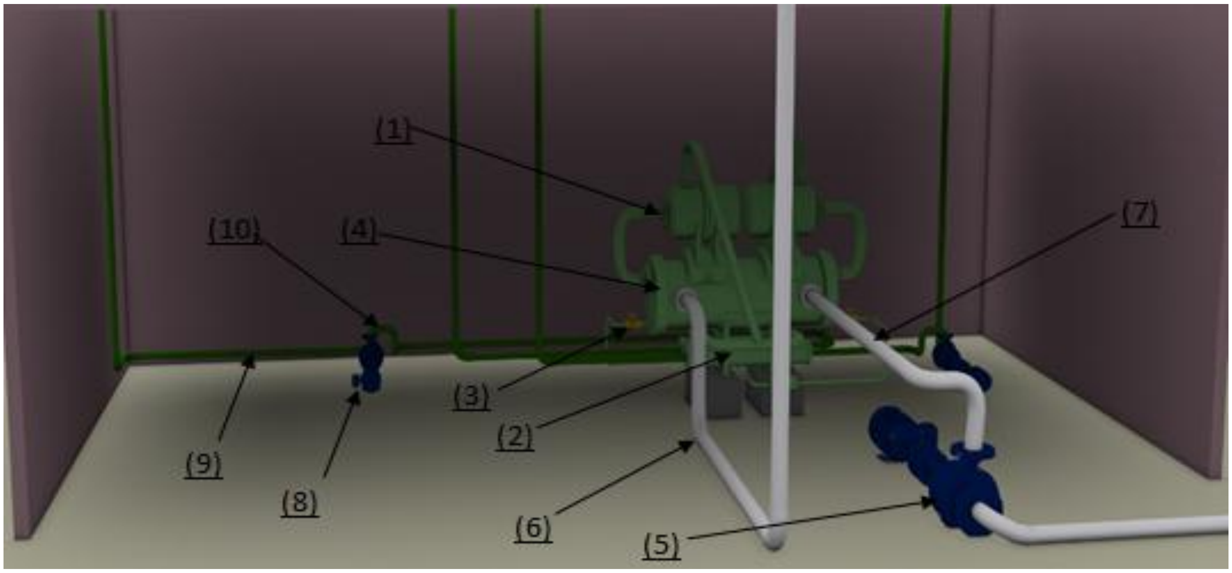

Figure 3-4 Main components of chiller system.

1-compressor 2-condenser 3-Expansion valve 4- Evaporator
5-chilled water pump 6-line of chilled water leaving evaporator 7- line of chilled water entering evaporator
8-cooling water pump 9-suction of cooling water pump 10- Discharge of cooling water pump

3-2-1-1The Compressor

The purpose of the compressor is to draw the low-temperature, low-pressure vapor from the evaporator via the suction line. Once drawn, the vapor is compressed. When vapor is compressed its temperature rises. Therefore, the compressor transforms the vapor from a low-temperature vapor to a high-temperature vapor, in turn increasing the pressure. The vapor is then released from the compressor in to the discharge line, a hot gas or discharge line delivers the high-pressure, high-temperature vapor from the discharge of the compressor to the condenser, the type of compressor used is screw compressor. shown in figure3.5 below

Figure 3-5 Screw compressors.

3-2-1-2 The condenser

The purpose of the condenser is to extract heat from the refrigerant to the outside air. Fans mounted above the condenser unit are used to draw air through the condenser coils. The temperature of the high-pressure vapor determines the temperature at which the condensation begins. As heat has to flow from the condenser to the air, the condensation temperature must be higher than that of the air. The high-pressure vapor within the condenser is then cooled to the point where it becomes a liquid refrigerant once more, whilst retaining some heat. The liquid refrigerant then flows from the condenser in to the liquid line. the type of condenser used is Water cooled condenser, shown in figure3-6 below

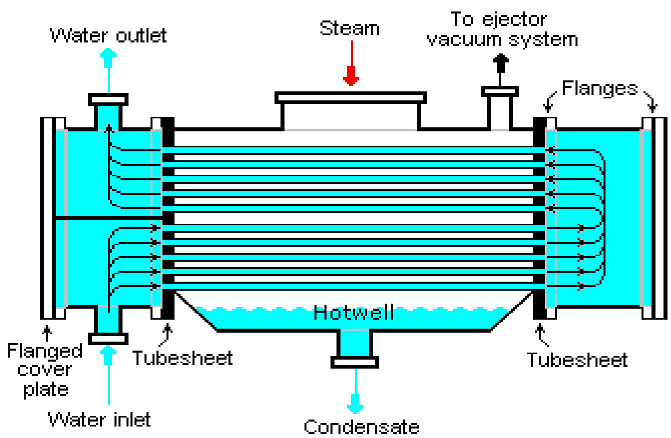

Figure 3-6 Water cooled condenser.

3-2-1-3 The Expansion Valve

The expansion valve is located at the end of the liquid line, before the evaporator. The high-pressure liquid reaches the expansion valve, having come from the condenser. The valve then reduces the pressure of the refrigerant as it passes through the orifice, which is located inside the valve. On reducing the pressure, the temperature of the refrigerant also decreases to a level below the surrounding air. This low-pressure, low-temperature liquid is then pumped in to the evaporator; the type of expansion valve used is Thermostatic expansion valve (E .V). Shown in figure3-7 below

Figure 3-7 Thermostatic expansion devices.

3-2-1-4 The Evaporator

The purpose of the evaporator is to remove unwanted heat from the space, via the liquid refrigerant. The liquid refrigerant contained within the evaporator is boiling at a low-pressure; the temperature of the liquid refrigerant must be lower than the temperature of the space being cooled. Once transferred, the liquid refrigerant is drawn from the evaporator by the compressor via the suction line. When leaving the evaporator coil the liquid refrigerant is in vapor form, the type of evaporator used is Water-Cooling Evaporators (Chilled Water). Shown in figure3-8 below

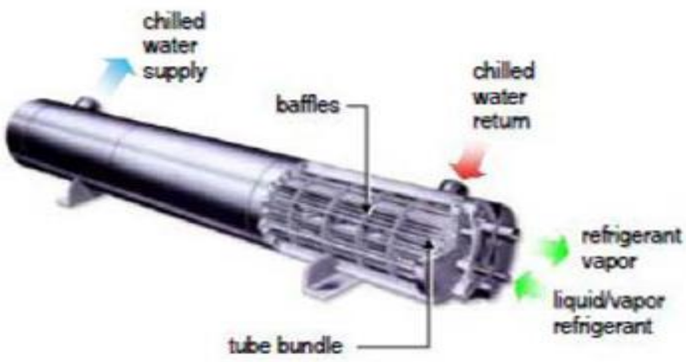

Figure 3-8 Water-Cooling Evaporator (Chilled Water).

3-2-2 Cooling tower

A cooling tower is a heat rejection device which rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. it is containing fan, water distribution, drift eliminators and transfer pump, the type of cooling tower used is cross-flow of cooling water ,shown in figure3-9 below

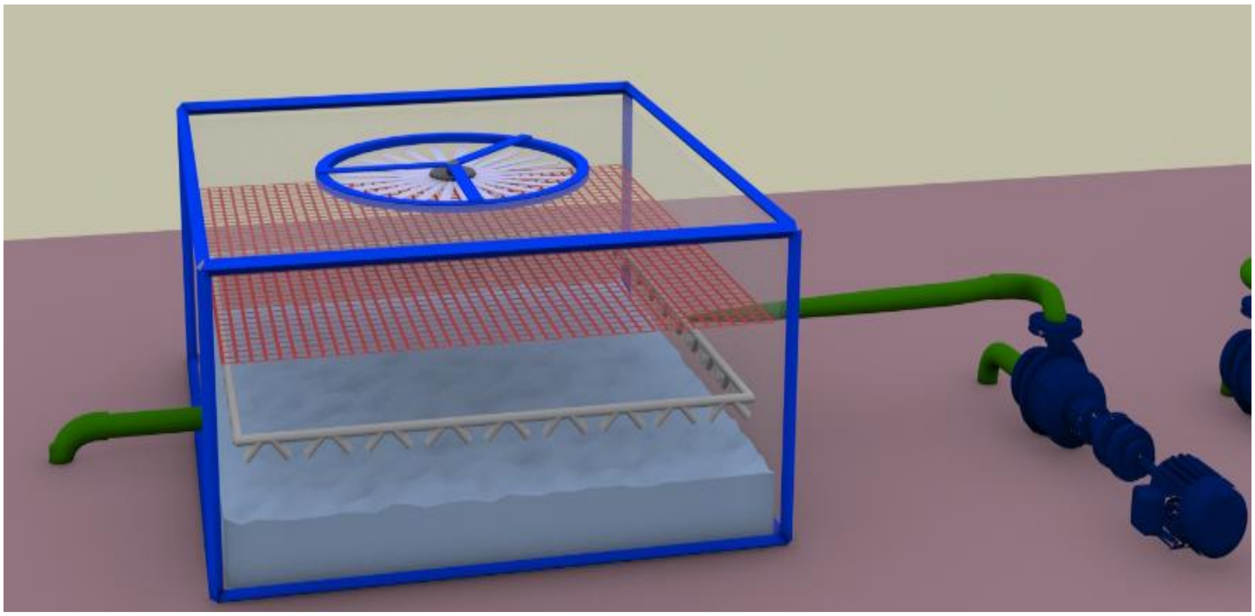

Figure 3-9 cross-flow of cooling water.

3-2-3 Heat exchange

Heat exchanger is use to transfer heat between ambient air and chilled water, the type of heat exchanger used cross flow heat exchanger, it is containing Chilled coils consist of tubes pass through plates and Drain system to remove condensed water, the below figure 3-10 shown the cross flow heat exchanger.

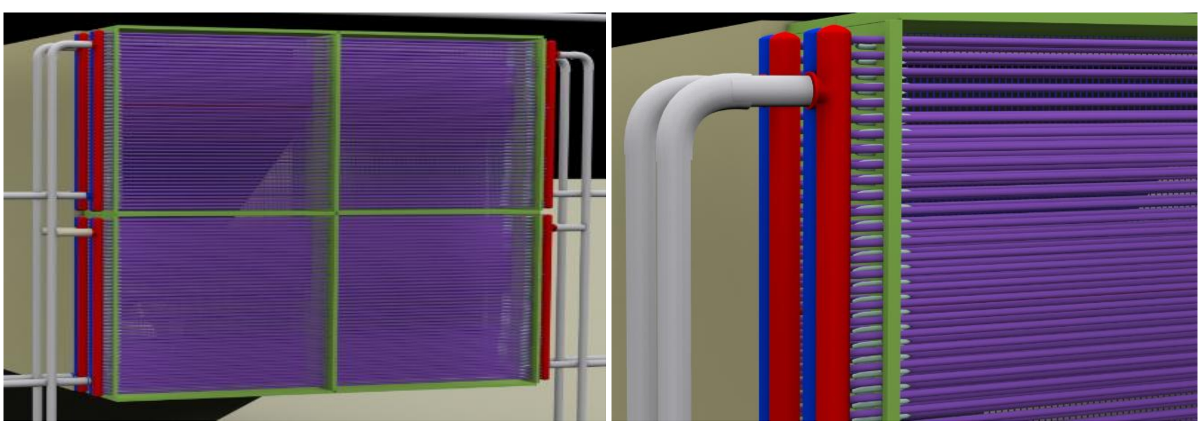

Figure 3-10 Cross flow heat exchange