**Design Calculation**

The design calculation enlists the calculations used in obtaining the mass of flow rate of steam, total heat added, heat loss, steam turbine work, pump work, net cycle work, thermal efficiency and steam rate.

**Table 2.0**

**Summary of Calculation for Design Option 1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Equation** | **Symbol** | **Value** | **Units** |
| Mass flow rate of steam | ms = Pout/Wnet | ms | 664.92 | kg/s |
| Heat added in the boiler | Qb = ms(h1-h23) | Qb | 1,292,566.46 | kW |
| Heat added in the reheater | Qrh = (m1-m2)(h4-h3) | Qrh | 191,883.39 | kW |
| Heat Loss | Ql = (m23-m2-m5-m6-m7-m8)(h9a-h10) | Ql | 984,449.85 | kW |
| Turbine Work | Wt = m23(h1-h2a) + (m23-m2)(h2a-h3) + (m23-m2)(h4-h5a) + (m23-m2-m5)(h5a-h6a) + (m23-m2-m5-m6)(h6a-h7a) + (m23-m2-m5-m6-m7)(h7a-h8a) + (m23-m2-m5-m6-m7-m8)(h8a-h9a) | Wt | 514,083.00 | kW |
|
|
|
| Pump Work | Wp = (h11 - h10) + (h13-h12) + (h19-h18) | Wp | 14,843.58 | kW |
| Total Heat Added | Qa = Qb + Qrh | Qa | 1,484,449.85 | kW |
| Net Cycle Work | Wnet = Qa - Ql | Wnet | 500,000 | kW |
| Thermal Efficiency | eth = Wnet/Qa | eth | 33.68 | % |
| Steam Rate | SR = 3600/Wnet | SR | 0.0072 | kg/kWh |
| Generator Efficiency | eg = Gen. Output/Wt | eg |  | % |

This table shows the different parameters used to calculate the thermal efficiency of a reheat regenerative cycle for Design Option 1. The heat added and rejected of the cycle is determined by the energy balance equation for the system. Similarly, the turbine work and pump work is obtained by getting the difference of the enthalpies between the inlet and outlet of the component. The results obtained are based on the capacity of the coal fired power plant which is 500 MW. The design option 1 shows that the thermal efficiency is about 33.68%.

**Table 3.0**

**Summary of Calculation for Design Option 2**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Equation** | **Symbol** | **Value** | **Units** |
| Mass flow rate of steam | ms = Pout/Wnet | ms | 654.58 | kg/s |
| Heat added in the boiler | Qb = ms(h1 - h26) | Qb | 1,272,454.21 | kW |
| Heat added in the reheater | Qrh = (m1 - m2)(h4 - h3) | Qrh | 188,897.70 | kW |
| Heat Loss | Ql = (m26 - m2 - m5 - m6 - m7 - m8)(h10a-h11) | Ql | 961,351.90 | kW |
| Turbine Work | Wt = m26(h1-h2a) + (m26-m2)(h2a-h3) + (m26-m2)(h4-h5a) + (m26-m2-m5)(h5a-h6a) + (m26-m2-m5-m6)(h6a-h7a) + (m26-m2-m5-m6-m7)(h7a-h8a) + (m26-m2-m5-m6-m7-m8)(h8a-h9a) + (m26-m2-m5-m6-m7-m8-m9)(h9a-h10a) | Wt | 513,512.02 | kW |
|
|
|
| Pump Work | Wp = (h12 - h11) + (h14-h13) + (h22-h21) | Wp | 14,264.86 | kW |
| Total Heat Added | Qa = Qb + Qrh | Qa | 1,461,351.91 | kW |
| Net Cycle Work | Wnet = Qa - Ql | Wnet | 500,000 | kW |
| Thermal Efficiency | eth = Wnet/Qa | eth | 34.21 | % |
| Steam Rate | 3600/Wnet | SR | 0.0072 | kg/kWh |
| Generator Efficiency | eg = Gen. Output/Wt | eg |  | % |

This table shows the different parameters used to calculate the thermal efficiency of a reheat regenerative cycle for Design Option 2. The heat added and rejected of the cycle is determined by the energy balance equation for the system. Similarly, the turbine work and pump work is obtained by getting the difference of the enthalpies between the inlet and outlet of the component. The results obtained are based on the capacity of the coal fired power plant which is 500 MW. The design option 1 shows that the thermal efficiency is about 34.21%.

**Table 4.0**

**Summary of Calculation for Design Option 3**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Equation** | **Symbol** | **Value** | **Units** |
| Mass flow rate of steam | ms = Pout/Wnet | ms | 646.41 | kg/s |
| Heat added in the boiler | Qb = ms(h1 - h32) | Qb | 1,241,645.93 | kW |
| Heat added in the reheater | Qrh = (m32- m2-m3)(h5 - h4) | Qrh | 183,569.25 | kW |
| Heat Loss | Ql = (m32 - m2 - m3 - m6 - m7 - m8 - m9 - m10 - m11)(h9a-h10) | Ql | 925,215.19 | kW |
| Turbine Work | Wt = m32(h1-h2a) + (m32-m2)(h2a-h3a) + (m32-m2-m3)(h3a-h4) + (m32-m2-m3)(h5-h6a) + (m32-m2-m3-m6)(h6a-h7a) + (m32-m2-m3-m6-m7)(h7a-h8a) + (m32-m2-m3-m6-m7-m8)(h8a-h9a) + (m32-m2-m3-m6-m7-m8-m9)(h9a-h10a) + (m32-m2-m3-m6-m7-m8-m9-m10)(h10a-h11a) +(m32-m2-m3-m6-m7-m8-m9-m10-m11)(h11a-12a) | Wt | 512,859.36 | kW |
|
|
|
| Pump Work | Wp = (h14 - h13) + (h16-h15) + (h26-h25) | Wp | 12,369.08 | kW |
| Total Heat Added | Qa = Qb + Qrh | Qa | 1,425,215.18 | kW |
| Net Cycle Work | Wnet = Qa - Ql | Wnet | 500,000 | kW |
| Thermal Efficiency | eth = Wnet/Qa | eth | 35.08 | % |
| Steam Rate | 3600/Wnet | SR | 0.0072 | kg/kWh |
| Generator Efficiency | eg = Gen. Output/Wt | eg |  | % |

This table shows the different parameters used to calculate the thermal efficiency of a reheat regenerative cycle for Design Option 3. The heat added and rejected of the cycle is determined by the energy balance equation for the system. Similarly, the turbine work and pump work is obtained by getting the difference of the enthalpies between the inlet and outlet of the component. The results obtained are based on the capacity of the coal fired power plant which is 500 MW. The design option 1 shows that the thermal efficiency is about 35.08%.