International Journal of Research in Advanced Engineering and Technology
ISSN: 2455-0876
Impact Factor: RJIF 5.44
www.newengineeringjournal.in
Volume 4; Issue 3; September 2018; Page No. 01-06

Use of cooling water in coal fired thermal power plants to hydro-electric power plants development

Pravin Bhagwat Khachane[1]
[1] PGD in Energy Management BE (Mechanical), Plot No 26, Ganesh Colony, Jalgaon Road, Bhusawal, Jalgaon, Maharashtra, India

Abstract
This report deals with use of cooling water in 25MWe to 500 MWe coal fired thermal power plants to Hydro-electric power plants development. The water required for condensation of steam in condenser ranges from 1 m^3/sec to 20 m^3/sec from 25 MWe to 500 MWe capacity coal fired thermal power plants. This large quantity of water is taken from nearby river or reservoir with the help of pumping station. After complete process of condensation cooling water is again send to river or reservoir which has natural head(ranges from 2 to 10m) or gauge pressure(ranges from 0.2 to 1barg pressure).This water has very high pressure energy, this pressure energy can be converted into electrical energy with the help of Kaplan type hydro-electric power plant installation. This generation of electricity from hydro-electric power plant will be ranges from 16 KWe to 1628 KWe in which CO_2 emission reduction will be ranges from 173 to 17,363 tons per year and required coal reduction for generation of electricity will be ranges from 62,400 to 62,53,714 kg per year.

Keywords: cooling water, coal-fired thermal power plant, hydro-electric power plant, river or reservoir, natural head, kaplan turbine, co_2 emission reduction, required coal reduction

Introduction

Energy is all around us; we make use of it, harness it, change it–it is an aspect of everyday life. This factsheet covers "use of cooling water in coal fired thermal power plants to hydro-electric power plants development"–sources and carrier, the global energy system, CO_2 emission reduction and cost saving, re-use options in the Resource, Recovery and Safe Reuse (RRR) sector. The Mission is to develop products which can harness the waste energy from existing coal fired thermal power plant in order to maximize efficiency and to reduce the energy demand load on environment, to reduce CO_2 emission in environment and reduction of use of coal for power generation. In all over the world there is lot of GWe capacity of coal fired thermal power plant, which is primary source of power generation in whole world. There is two options for condensation of steam in closed loop rankine cycle for again pumping purpose.1st is air cooler and 2nd is water cooler, area and auxiliary electrical power consumption requirement for air cooler is very high compared to water cooler. In case of water cooler water requirement is very high in quantity but auxiliary consumption, area requirement and manufacturing cost of coal fired power plant also reduces. So lot of coal fired thermal power plants are installed near riverside from which high quantity of water can be take. So there is installation of pumping station near riverside which pumps water to condenser of coal fired thermal power plant and after complete process of condensation again this water is send to river which has natural head ranges from 2 to 10m or gauge pressure 0.2 to 1barg.This pressure energy is wastage of energy, if Kaplan type hydro-electric power plant is installed huge energy recovery can be done from this waste energy.

Materials and method

Cooling water in coal fired thermal power plant to hydro-electric power plant" consist of four main components River or Reservoir, Pumping station, Condenser in coal fired thermal power plant and Power house(consist of Kaplan turbine coupled with generator, transformer).

As shown in below schematic diagram

1. **River or Reservoir:** River or Reservoir is very big source of water supply to the thermal Power plant, lot of thermal power plants are installed near riverside to provide sufficient Water supply, due to this reason water cooler type condenser is used in lot of cases where river is nearby to thermal power station.
2. **Pumping Station:** Pumping station is used for pumping water from River or Reservoir to thermal Power Station.
3. **Condenser in coal fired thermal power plant:** Most of the condensers in coal fired thermal power plants near riverside is cooling water type due to availability of large quantity of water supply, after complete process of condensation of steam in closed loop rankine cycle cooling water is rejected upto 55-65 deg. cel.
4. **Strainer:** Strainer is used for trapping the impurities in cooling water after condensation Process otherwise that impurities will damage the turbine blades. Design pressure of strainer should be upto 0.5 barg and design temperature of strainer should be upto 80 deg. cel.
5. **Penstock:** Penstock is used for condenser reject water supply to river or reservoir with natural head. Horizontal distance of penstock can be upto 5 kms also, so due to natural convection temp. Of cooling water reduces to environmental temp.

6. **Inlet and by-pass gate:** Inlet and By-pass gates are end connections of penstock. Inlet gate is OPEN when power generation in power house is working at that time By-pass gate is CLOSE, but when maintenance of Hydro-electric power plant takes place By-pass gate is OPEN and Inlet gate is CLOSE.
7. **Power house:** Power House consist of Kaplan turbine coupled with generator, transformer etc. Kaplan turbine capacity can be selected referring below "analysis chart-1", Generator and transformer can be selected considering "chart-2" parameters. Transformer is connected to grid for transmission of electricity.
8. **Tail race:** Tail race head is subtraction of Gross head and natural head. Tail race is provided for free flow of water in river or reservoir after complete process in power house or by By-pass gate.

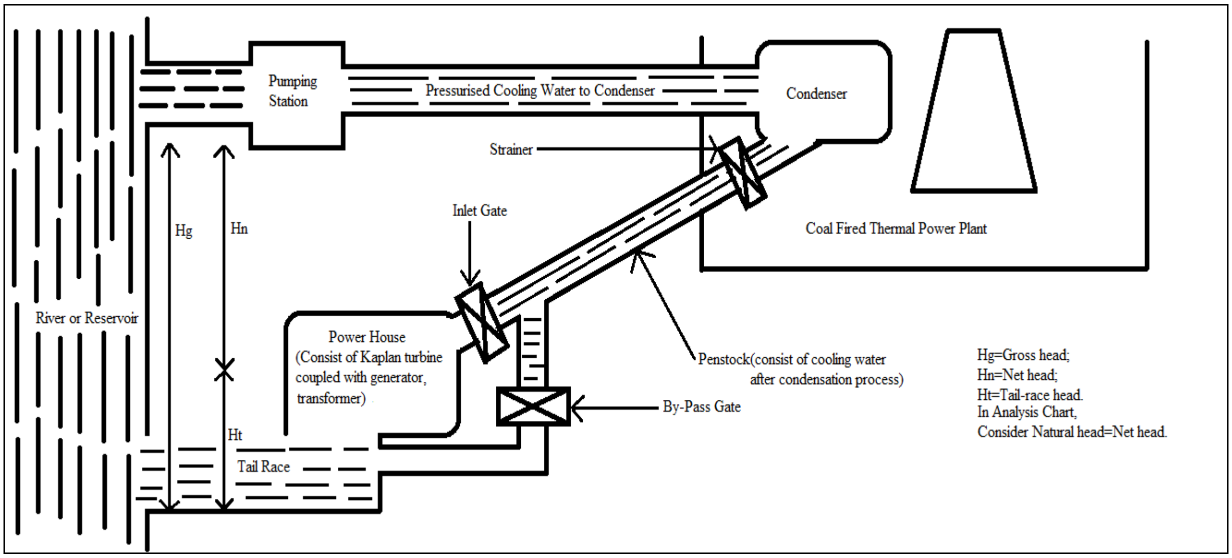

Fig 1: Schematic diagram of "Use of cooling water in coal fired thermal power plant to hydro-electric power development"

Results and discussion

Analysis Table 1

Table 1

	Input			Output		
Sr. No.	**Thermal power plant capacity (Mwe)**	**Flow rate of cooling water (m3/sec)**	**Natural head(m) (0.1 barg=1 m)**	**Hydro-electric Power Generation (Kwe)**	**Co2 emission reduction (tons per year)**	**Saving in coal (kg per year)**
1	25	1	2	16	173.25	62,400
2	25	1	3	24	260	94,080
3	25	1	4	33	346.5	1,24,800
4	25	1	5	41	434	1,56,480
5	25	1	6	49	519.75	1,87,200
6	25	1	7	57	608	2,18,880
7	25	1	8	65	695	2,50,149
8	25	1	9	73	781	2,81,417
9	25	1	10	81	868	3,12,686
10	50	2	2	33	346.5	1,24,800
11	50	2	3	49	520	1,88,160
12	50	2	4	65	693	2,49,600
13	50	2	5	81	869	3,12,960
14	50	2	6	98	1039.5	3,74,400
15	50	2	7	114	1215	4,37,760
16	50	2	8	130	1389	5,00,297
17	50	2	9	147	1563	5,62,834
18	50	2	10	163	1736	6,25,371
19	75	3	2	49	519.75	1,87,200
20	75	3	3	73	780	2,82,240
21	75	3	4	98	1039.5	3,74,400
22	75	3	5	122	1303	4,69,440
23	75	3	6	147	1559.25	5,61,600
24	75	3	7	171	1823	6,56,640

25	75	3	8	195	2084	7,50,446
26	75	3	9	220	2344	8,44,251
27	75	3	10	244	2604	9,38,057
28	100	4	2	65	693	2,49,600
29	100	4	3	98	1040	3,76,320
30	100	4	4	130	1386	4,99,200
31	100	4	5	163	1738	6,25,920
32	100	4	6	195	2079	7,48,800
33	100	4	7	228	2431	8,75,520
34	100	4	8	261	2778	10,00,594
35	100	4	9	293	3125	11,25,669
36	100	4	10	326	3473	12,50,743
37	125	5	2	81	866.25	3,12,000
38	125	5	3	122	1299	4,70,400
39	125	5	4	163	1732.5	6,24,000
40	125	5	5	204	2172	7,82,400
41	125	5	6	244	2598.75	9,36,000
42	125	5	7	285	3039	10,94,400
43	125	5	8	326	3473	12,50,743
44	125	5	9	366	3907	14,07,086
45	125	5	10	407	4341	15,63,429
46	150	6	2	98	1039.5	3,74,400
47	150	6	3	147	1559	5,64,480
48	150	6	4	195	2079	7,48,800
49	150	6	5	244	2607	9,38,880
50	150	6	6	293	3118.5	11,23,200
51	150	6	7	342	3646	13,13,280
52	150	6	8	391	4167	15,00,891
53	150	6	9	440	4688	16,88,503
54	150	6	10	489	5209	18,76,114
55	175	7	2	114	1212.75	4,36,800
56	175	7	3	171	1819	6,58,560
57	175	7	4	228	2425.5	8,73,600
58	175	7	5	285	3041	10,95,360
59	175	7	6	342	3638.25	13,10,400
60	175	7	7	399	4254	15,32,160
61	175	7	8	456	4862	17,51,040
62	175	7	9	513	5469	19,69,920
63	175	7	10	570	6077	21,88,800
64	200	8	2	130	1386	4,99,200
65	200	8	3	195	2079	7,52,640
66	200	8	4	261	2772	9,98,400
67	200	8	5	326	3476	12,51,840
68	200	8	6	391	4158	14,97,600
69	200	8	7	456	4862	17,51,040
70	200	8	8	521	5556	20,01,189
71	200	8	9	586	6251	22,51,337
72	200	8	10	651	6945	25,01,486
73	225	9	2	147	1559.25	5,61,600
74	225	9	3	220	2339	8,46,720
75	225	9	4	293	3118.5	11,23,200
76	225	9	5	366	3910	14,08,320
77	225	9	6	440	4677.75	16,84,800
78	225	9	7	513	5469	19,69,920
79	225	9	8	586	6251	22,51,337
80	225	9	9	660	7032	25,32,754
81	225	9	10	733	7813	28,14,171
82	250	10	2	163	1732.5	6,24,000
83	250	10	3	244	2599	9,40,800
84	250	10	4	326	3465	12,48,000
85	250	10	5	407	4345	15,64,800
86	250	10	6	489	5197.5	18,72,000
87	250	10	7	570	6077	21,88,800

88	250	10	8	651	6945	25,01,486
89	250	10	9	733	7813	28,14,171
90	250	10	10	814	8682	31,26,857
91	275	11	2	179	1905.75	6,86,400
92	275	11	3	269	2859	10,34,880
93	275	11	4	358	3811.5	13,72,800
94	275	11	5	448	4779	17,21,280
95	275	11	6	537	5717.25	20,59,200
96	275	11	7	627	6685	24,07,680
97	275	11	8	717	7640	27,51,634
98	275	11	9	806	8595	30,95,589
99	275	11	10	896	9550	34,39,543
100	300	12	2	195	2079	7,48,800
101	300	12	3	293	3119	11,28,960
102	300	12	4	391	4158	14,97,600
103	300	12	5	489	5213	18,77,760
104	300	12	6	586	6237	22,46,400
105	300	12	7	684	7292	26,26,560
106	300	12	8	782	8334	30,01,783
107	300	12	9	879	9376	33,77,006
108	300	12	10	977	10418	37,52,229
109	325	13	2	212	2252.25	8,11,200
110	325	13	3	318	3378	12,23,040
111	325	13	4	423	4504.5	16,22,400
112	325	13	5	529	5648	20,34,240
113	325	13	6	635	6756.75	24,33,600
114	325	13	7	741	7900	28,45,440
115	325	13	8	847	9029	32,51,931
116	325	13	9	953	10157	36,58,423
117	325	13	10	1058	11286	40,64,914
118	350	14	2	228	2425.5	8,73,600
119	350	14	3	342	3638	13,17,120
120	350	14	4	456	4851	17,47,200
121	350	14	5	570	6082	21,90,720
122	350	14	6	684	7276.5	26,20,800
123	350	14	7	798	8508	30,64,320
124	350	14	8	912	9723	35,02,080
125	350	14	9	1026	10939	39,39,840
126	350	14	10	1140	12154	43,77,600
127	375	15	2	244	2598.75	9,36,000
128	375	15	3	366	3898	14,11,200
129	375	15	4	489	5197.5	18,72,000
130	375	15	5	611	6517	23,47,200
131	375	15	6	733	7796.25	28,08,000
132	375	15	7	855	9116	32,83,200
133	375	15	8	977	10418	37,52,229
134	375	15	9	1099	11720	42,21,257
135	375	15	10	1221	13022	46,90,286
136	400	16	2	261	2772	9,98,400
137	400	16	3	391	4158	15,05,280
138	400	16	4	521	5544	19,96,800
139	400	16	5	651	6951	25,03,680
140	400	16	6	782	8316	29,95,200
141	400	16	7	912	9723	35,02,080
142	400	16	8	1042	11112	40,02,377
143	400	16	9	1172	12501	45,02,674
144	400	16	10	1303	13890	50,02,971
145	425	17	2	277	2945.25	10,60,800
146	425	17	3	415	4418	15,99,360
147	425	17	4	554	5890.5	21,21,600
148	425	17	5	692	7386	26,60,160
149	425	17	6	831	8835.75	31,82,400
150	425	17	7	969	10331	37,20,960

151	425	17	8	1107	11807	42,52,526
152	425	17	9	1246	13283	47,84,091
153	425	17	10	1384	14759	53,15,657
154	450	18	2	293	3118.5	11,23,200
155	450	18	3	440	4678	16,93,440
156	450	18	4	586	6237	22,46,400
157	450	18	5	733	7820	28,16,640
158	450	18	6	879	9355.5	33,69,600
159	450	18	7	1026	10939	39,39,840
160	450	18	8	1172	12501	45,02,674
161	450	18	9	1319	14064	50,65,509
162	450	18	10	1466	15627	56,28,343
163	475	19	2	309	3291.75	11,85,600
164	475	19	3	464	4938	17,87,520
165	475	19	4	619	6583.5	23,71,200
166	475	19	5	774	8255	29,73,120
167	475	19	6	928	9875.25	35,56,800
168	475	19	7	1083	11546	41,58,720
169	475	19	8	1238	13196	47,52,823
170	475	19	9	1392	14845	53,46,926
171	475	19	10	1547	16495	59,41,029
172	500	20	2	326	3465	12,48,000
173	500	20	3	489	5198	18,81,600
174	500	20	4	651	6930	24,96,000
175	500	20	5	814	8689	31,29,600
176	500	20	6	977	10395	37,44,000
177	500	20	7	1140	12154	43,77,600
178	500	20	8	1303	13890	50,02,971
179	500	20	9	1466	15627	56,28,343
180	500	20	10	1628	17363	62,53,714

Note: 1 Flow rate of cooling water can be vary ±10% according to thermal power plant condition, then Hydro-electric power generation will be also vary in same ratio(Because flow rate is directly proportional to Hydro-electric power generation.) 2. Consider, Natural head=Net head.

Table 2: Selection of Generator and Transformer (chart-2)

Sr. No.	Particulars	Specifications
1	Selection of generator	1. Type 2. Rated output (kva or mvarating, phase supply, frequency) 3. Voltage rating 4. Power factor(lagging) 5. Insulation 6. Excitation System 7. Make
2	Selection of transformer	1. Step up transformer capacity. 2. Connection on input side. 3. Connection on output side. 4. Connection point. 5. Protection system. 6. Control and monitoring. 7. Circuit breakers

Note: 1 From “Analysis Table 1” power generated in Kwe is taken as input for selection of generator and transformer (Considering above specifications). 2) Selection of Generator and Transformer depends on Location, Vendor development and project cost.

Table 3: Project Execution Management

Sr. No.	Particulars	Details	Duration (months)
1	To make Detail “Design Project report” and NOC of land	1. This type of audit offers the most accurate estimate of energy savings and cost. 2. Land audit of location where power house will be locate by professional auditor. 3. Take complete commercial proposals from implementing agencies like vendors and contractors. 4. Take non objection certificate (NOC) of land from govt. authorities.	3
2	After selection of land make	1. Calculation of flow rate of cooling water for continuous 15 days. 2. Calculation of head loss in pipe for calculation of net head.	0.5

	"Energy Audit"	3. Decision on what should be the tail race head for free flowing of water again in river or reservoir.	
3	Selection Procedure	1. Selection of turbine, generator and transformer and development of vendors.(referring above charts)	0.5
4	Manufacturing	1. Manufacturing of turbine, generator and transformer. 2. Civil construction of power house with by-pass lining,tail race structure.	9
5	Installation, testing and inspection	1. Assembly of all parts. 2. To make transformer to grid connection arrangement. 3. Testing of whole set-up. 4. Inspection by authority persons to make feasibility report of hydro-electric power plant.	5
Total Duration			18

Conclusion

1. In this project no need to develop Trench weir, channel, forebay, penstock etc., so civil work reduces by 60% only mounting of "power house structure", by-pass lining and tail race structure will take place. due to civil work reduction, cost of project also reduces.
2. If we develop Hydro-power plant, payback for Hydro-electric power plant will be get in only 30months (With compared to production cost of coal fired thermal power plant).
3. Equipments required for Hydro-electric power plant is 40% of conventional coal fired steam power plant (Boiler, condenser, pump with motor, valves and piping reduces in Hydro-electric power plant).
4. Hydro-electric power plant has not any production cost. (Like bituminous coal etc.
5. Hydro-electric power plant has not any CO2 emission so it does not create any environmental impact.
6. This additional projects will give regular employment for local peoples and revenue generation for local government.

References

1. Power Plant Engineering. By A.k. Raja, Amit shrivastva and manish dwivedi.
2. Introduction to Hydro Energy Systems: Basics, Technology and Operation Book by Hermann-Josef Wagner and Jyotirmay Mathur.
3. Alexandra von Meier. Electric power systems: a conceptual introduction john wiley and sons publication. 2006; 8:309.