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Solar power and desalination plant for carbon black industry: Improvised techniques

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Abstract

In India, continuous production of electricity and sweet/potable water from Solar power and desalination plant plays a major role in the industries. Particularly in Carbon black industry, Solar power adopts Solar field collector combined with thermal storage system and steam Boiler, Turbine & Generator (BTG) for electricity production and desalination plant adopts Reverse osmosis (RO) for sweet/potable water production which cannot be used for long hours of power generation and consistency of energy supply for industrial processes and power generation cannot be ensured. This paper presents an overview of enhanced technology for Solar power and Desalination plant for Carbon black industry making it continuous production of electricity and sweet/potable water. The conventional technology can be replaced with this proposed technique in the existing and upcoming industries.
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Keywords: Solar; Solar thermal hybrid power plant; Solar thermal hybrid power plant with desalination plant; Improvised techniques; CSP-biomass hybrid

1. Introduction

India has tremendous solar potential which can be utilized to meet its fast growing industrial electricity requirements. The industries have been instrumental in promotion & deployment of solar energy systems as India is endowed with large solar energy potential whereby about 5000 trillion kW h per year energy is incident over India's land area with most parts receiving 4–7 kW h per sq. m. per day with almost 300 sunny days.

In earlier days, Carbon black industries utilized Solar power and desalination (Palenzuela et al., 2011) in day time. Nowadays, Carbon black industries are focusing more on adoption of round the clock production of Solar power and desalination plants to meet their demands. This paper presents a clear picture about continuous production of electricity and sweet/potable water using enhanced techniques and ensuring round the clock production of electricity and sweet/potable water. Also this technology ensures to get high quality of permeate water which can be used within the Carbon black industry as process water/cooling tower make up water/potable water and for obtaining rejects with high Total Dissolved Solids (TDS) which is being disposed as feed water to Salt production units.

2. Site observations on Solar power and desalination plants and its schemes

Normally in Carbon black industries, Solar power and desalination plant (Palenzuela et al., 2011) comprise of

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solar fields combined with thermal storage system power plant and Reverse osmosis (RO) (Attia, 2012; Antipova et al., 2013; Manolakos et al., 2009; Pérez-González et al., 2012; França et al., 2000; Song et al., 2002; Tan et al., 2012) desalination plant. Solar energy is received through solar field collectors (Nixon et al., 2010) in the form of heat and transferred to Heat transfer fluids (Esen, 2000; López-González et al., 2013) (HTF) by means of heat conduction. The steam boiler produces steam by heating the circulated demineralised (DM) water with HTF. The superheated steam thus produced from boiler rotates turbine and generator to produce electricity and supplies through grid to end users.

The source of water for RO desalination plant is seawater. The typical quality of seawater obtained from Bay of Bengal Sea is shown in Table 1.

The initial separation of suspended solids from the Sea water is accomplished by treating it in Pretreatment plant. The separation of suspended solids is achieved in clarifier with the help of pretreatment chemicals like coagulant, flocculant etc. (Üstün et al., 2011). The sludge settles at the bottom of clarifier and handled in a separate sludge handling and disposal system. The clarified water from the clarifier is then stored in clarified water storage tank and then pumped to RO (Attia, 2012; Antipova et al., 2013; Manolakos et al., 2009; Pérez-González et al., 2012; França et al., 2000; Song et al., 2002; Tan et al., 2012) desalination plant as feed water to produce sweet/potable water. The power required to pump the clarified water to RO (Attia, 2012; Antipova et al., 2013; Manolakos et al., 2009; Pérez-González et al., 2012; França et al., 2000; Song et al., 2002; Tan et al., 2012) desalination plant is received from solar power (Zhang et al., 2015) plant.

The typical block diagram for seawater pretreatment plant in Carbon black industry is shown in Fig. 1.

Further, the clarified water from pretreatment plant is treated in RO (Attia, 2012; Antipova et al., 2013; Manolakos et al., 2009; Pérez-González et al., 2012; França et al., 2000; Song et al., 2002; Tan et al., 2012) desalination plant to get high quality process water which can be used within the carbon black industry to meet process water, cooling tower make up or potable water requirements.

The typical quality of permeate water obtained from a Reverse osmosis (RO) (Attia, 2012; Antipova et al., 2013; Manolakos et al., 2009; Pérez-González et al., 2012; França et al., 2000; Song et al., 2002; Tan et al., 2012) desalination plant is shown in Table 2.

3. Case study analysis and discussion

3.1. Case I: (as per site condition)

The typical block diagram (as per site condition) for solar power plant in carbon black industry is shown in Fig. 2.

- Heat transfer fluid (HTF) is heated up to 395 °C.
- Heat Surplus from solar field is stored into the thermal energy storage (TES) at times with high irradiation. The storage is then discharged in the evening hours or whenever required.
- The heat from the oil-loop serves as input for a conventional steam turbine (Rankine cycle).
- The steam turbine produces electricity.
- The power generated from this technology is fed into the grid and supplied to the State utility company or to other consumers.

The typical block diagram (as per site condition) for RO (Attia, 2012; Antipova et al., 2013; Manolakos et al., 2009; Pérez-González et al., 2012; França et al., 2000; Song et al., 2002; Tan et al., 2012) desalination plant in Carbon black industry is shown in Fig. 3.

Table 1
Quality of seawater obtained from Bay of Bengal for a Carbon black industry in India.

Sl no.	Parameters	Units	Values (Min–Max)
1	pH	–	7.9–8
2	Biochemical Oxygen Demand (BOD)	mg/l	1.1–3.8
3	Chemical Oxygen Demand (COD)	mg/l	1.0–1.4
4	Turbidity	NTU	9–15.8
5	Total Suspended Solids (TSS)	mg/l	52.9–86.7
6	Calcium	mg/l	391–482
7	Magnesium	mg/l	1136–1396
8	Chloride	mg/l	18,238–19,516
9	Sodium	mg/l	11,000 (Avg)
10	Silicates	μg/l	4.3–13.39
11	Boron	gm/l	3.4–3.7
12	Sulphate	gm/l	2.3–2.9
13	Iron Fe	ppb	441–1240
14	Arsenic (as As)	ppb	0–441
15	Copper (as Cu)	ppb	13–120
16	Chromium (as Cr)	ppb	0–32
17	Potassium (as K)	ppm	33–239
18	Total Dissolved Solids (TDS)	mg/l	31,856–35,981

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