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SCOPE OF NON-CONVENTIONAL SOURCES OF ENERGY IN PAPER INDUSTRIES

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Abstract

It is doubtless utterance to state that the increase in the population and literacy of our people, the demand of paper and paper based products is increasing day by day. The data available till date reveals us that by 2000 A.D., the paper and paper board demand should reach 42.5 lakhs tonnes per annum. In making such a quantity of paper product, 46.4 lakhs tonnes of coal shall be needed which is equivalent to 43,800 lakhs KWH of electrical energy.

For such a highly intensive, energy-oriented industry, both the thermal and the electrical energy contribute together in executing the various unit operations involved. Steam consumption of the order of 10.5 to 17.4 tonnes of steam per tonne of paper-product is essential energy requirement. At the same time, the electrical power consumption is only of the order of 23.4 per cent of total power required. Thus it may be stated that the paper industry is thermal-energy oriented industry. So, there is a vast scope of incorporating non-conventional means of energy to supplement a major poriton of total thermal energy. The present paper describes the use of non-conventional means of energy, like 'Solar Energy' in which both the beam and diffuse radiations are used to produce thermal energy.

Introduction

India has a significant level of solar insolation over wide ranges. The total solar energy received by Indian land-man annually is about 60×10^{13} MWH. There are about 300 useful shiny days per year in most parts of the country. Over 3000-3200 hours of bright sun-shine are received every year over Rajasthan, Gujarat, West Madhya Pradesh and North Maharashtra, and 2600-2800 hours over the rest of the country, except in Kerala, Assam and Kashmir, where they are appreciably lower. So, solar energy is available abundantly and is of the order of 5-7 kwh/m^2 in the central part of the country.

Solar Technology

Solar energy is taped by a suitably selected equipment known as Solar Collector (SC). The shape and design of SC, depends upon the temperature requirement. SC's, is used for generating a temperature below 100°C, are known as Flat Plate Collector, (FPC) while those generating higher temperature are known as Focussing Collector (FC).

FPC, comprises a blackened flat plate metal collector with attached metal Tubing, facing the general direction of the Sun. The collector is provided with a transparent glass cover and a layer of thermal insulation beneath the plate. The collector tubing is connected by a pipe to an insulated storage tank, that stores hot water during non-sunny periods. FPC, absorbs solar radiation and by transfer of resulting heat to the water circulating through the tubing, by gravity or by a pump. Fig. 1 exhibits the various details of the functioning elements of FPC.

The Number of FPC, required for a fixed capacity of hot water depends upon weather conditions like sunny, cloudy and over-cast and conditions of the sun-shine. Depending upon the thermal inertia, FPC's systems are arranged for a fixed temperature differential in one complete circulation of the fluid running within the FPC. Fig. 2 exhibits the various alternative arrangement for solar-energy collectors, 6x2 system. The different systems correspond to the three different weather conditions as shown:

Focussing-collectors (FC), which are also known as concentrating collectors, are used to generate high temperature heat. This heat may be converted to torque or electricity using conventional engines/turbines. FC, are again of two types, point focussing type and line focussing type. The point focussing type FC, may further be divided into two categories. First consisting a large number of sun tracking mirrors used to concentrate solar radiation. On to a Central point at the top of a Tower. Such systems are therefore called central-receiver systems. The second type of point focussing-collector (FC), are parabolic-dish type which was an array of two axis tracking system, having it's receiver mounted at the focal-point. The line focussing type of FC, are known as parabolic-through. Fig. 3 exhibits all

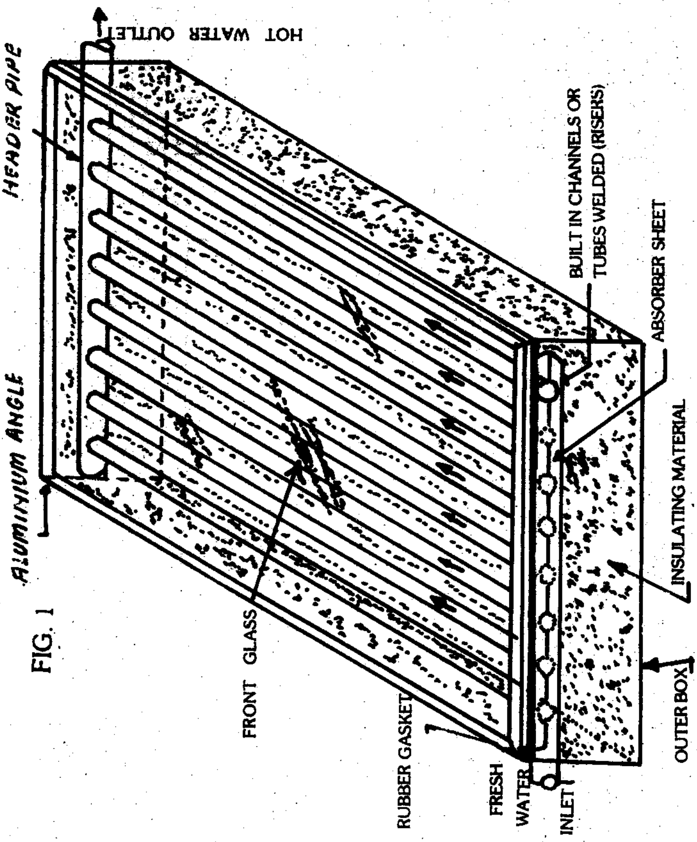
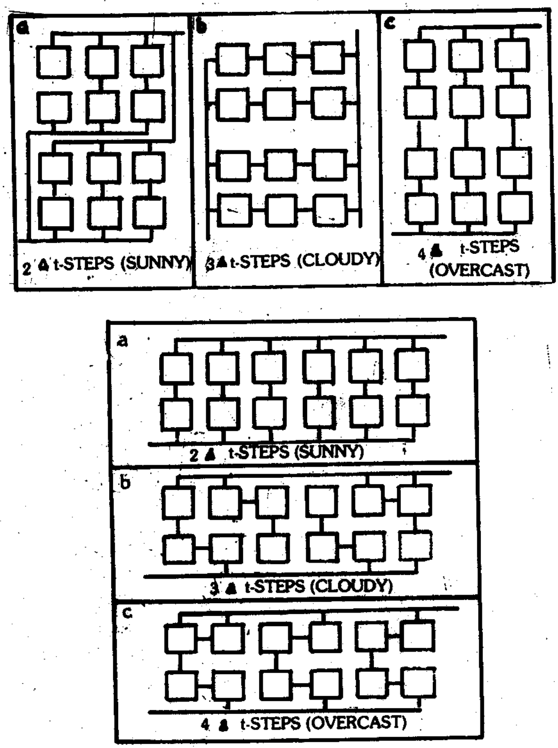


FIG. 1

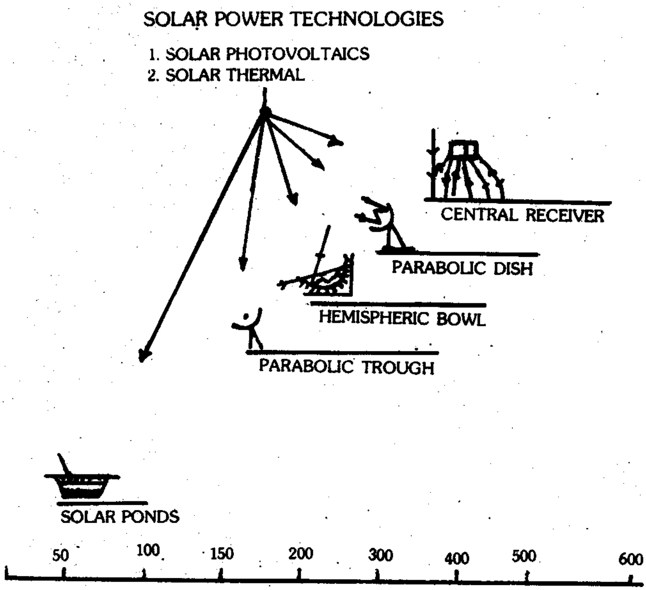
VARIOUS PARTS OF A FLAT PLATE SOLAR COLLECTOR

FIG. 2



ALTERNATIVE ARRANGEMENTS FOR SOLAR ENERGY COLLECTORS, 6x2 SYSTEM

FIG. 3



Techniques of electric power production from solar energy.

the three types of the focussing collector, showing their working temperature-ranges. In addition the solar-pond's working temperature range has also been exhibited.

Another important type of solar-collector, which is finding in roads in the solar thermal program, is evacuated tube solar-collector. It consists of a selectively coated absorber panel sealed within an evacuated glass tube ($p<10^{-3}$m bar). Due to minimum heat losses, such collectors are useful to generate a temperature in the vicinity of 150 degree celcius. But, in India, such collectors are still at the developmental stage. But, the work is on going at the different institutions and organisations.

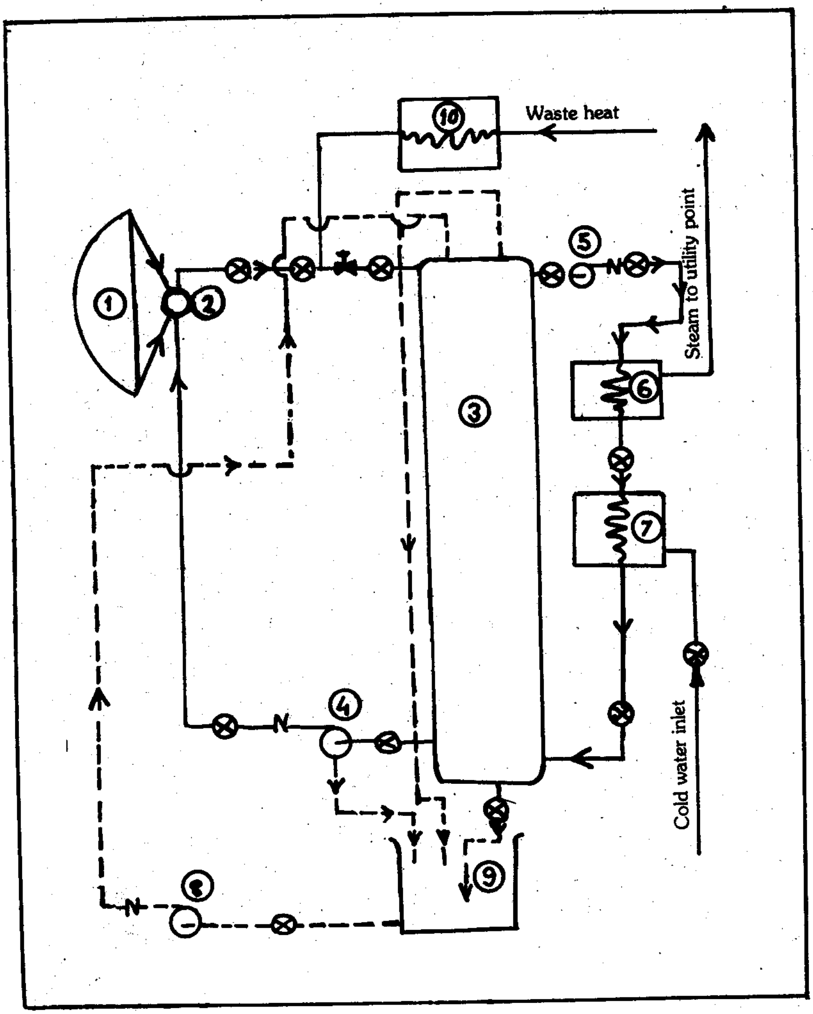
Application of solar system in paper industries

As it has been expressed in the preceding paragraphs that solar energy may be used to produce low temperature (i.e. below 100°C) using the flat plate collector while the high temperature of the order of 250-500°C may be attained by using the focussing type of the collectors. The energies obtained by two such modes may be termed as low grade and medium-grade energies. The next generation belonging to the high grade energy as used in solar-furnaces, generate a temperature of the order of few thousands degre celcius. In paper industries thermal energy of low and medium grades are required at the different stages of the unit operations and also for generating power by producing steam.

Solar systems possess an inherent advantage of being used as an independent unit to produce thermal energy of different grades, also there systems may be coupled with the waste heat available at the different stages of the paper industry. Fig. 4 illustrates such a system, where the solar-system alongwith the waste heat utilization system, is being used to generate steam as the utility point. Steam so produced may be directly used to produce for electricity generation or it may be diluted with appropriate media to impart thermal heat at a particular tempertaure. Various areas of thermal input to the paper industrties may be envisaged in the following manner, from the point of view of the application of non-conventional mode of energy.

* Supply of feed water to boiler (at 0°-90°)
* Supply of hot water for unit operations.
* Supply of hot water for different utilities.
* Supply of steam through heat exchange.

The operation like evaporations, drying which need thermal energy of low grade may be easily and conveniently obtained from the solar-systems using the flat-plate collector technology, for the operations like digestion and cooking. The steam may be directly fed from the system based on solar system as shown in the Fig. 4. Similarly steam requirement for power generator may also be met by using an appropriate solar system. So, it may


Waste heat
Steam to utility point
Cold water inlet
1
2
3
4
5
6
7
9
10
N
N
N
N

be inferred that a large portion of thermal energy may be either substituted or supplimented by using a solar thermal system. The concept at present may be taken as an affirmed assumption that non-conventional mode of energy may be proved quite useful for the paper industry. But, in real practice, an integrated approach has to be made balancing both the conventional and non-conventional modes of energies. Another, most important factor, in the solar program, is the proper selection of a suitable energy storage media and the energy transfer media. These two important parameters decide the operational temperature range and the energy storage capacity of the solar system. Strong capacity parameter is important from the point of view that it decides the total thermal requirement and also takes care during non-sunny period, for a definite temperature swing.

In the present paper the emphasis is made to compare the thermal energy obtained from the conventional and non-conventional mode of energy. But it should always be remembered that solar energy can not replace the existing energy sources, it can only supplement it as it is available only during the day time. Designing, a solar system, is obviously not as easy from the "efficieny point of view" as it may appear. It is merely a matter of optimization and most effectiveness rather than simply maximizing efficiency.

Energy savings:

Solar systems, mainly solar hot water systems developed in the country can heat water from the ambient temperature to a temperature of 90°C. The quantity of heat, needed to heat different volumes of water to the different tempertaures, is illustrated table 1. The same amount of energy may be saved by using a suntest non-conventional mode of energy the solar energy. This may be taken as a nett saving in the total energy requirement of the process industry like paper industry.

TABLE 1

Heat gain (kwh/year) for different capacities of water heaters for different temperature differences.

	Temperature difference of °C				
Capacity Litres	20	40	50	60	70
100	697.8	1395.6	1744.5	2093.4	2442.3
500	3489.0	6978.0	8722.5	10467.0	12211.5
1000	6978.0	13956.0	17445.0	20934.0	24423.0
3000	20934.0	41868.0	52335.0	62802.0	73269.0
5000	34890.0	69750.0	87225.0	104670.0	122115.0
20000	139560.0	279120.0	348900.0	414680.0	488460.0
50000	348900.0	697800.0	872250.0	1046700.0	1221150.0

TABLE 2

Expected Fuel Savings as a result of heating 100 ltres of water per day by 60°C using solar energy.

Fuel	Colorific value (K.Cal/Kg)	Thermal Efficiency(%)	Fuel saved (Kg.)
Firewood	4708	17.3	2138
Cowdung	2033	11.0	7726
Charcoal	6930	28.0	893
Kerosene	9122	50.0	380
LPG	10882	60.0	265
Soft Coke	6252	28.0	990
Electricity	--	90.0	2230 KWH (electrical)

Thus, solar hot water systems have come out as one of the novelest mode of energy saving devices in the different types of the industries. It is only the reason that a vast number of solar hot water systems have entered in so many commercial establishments such as Hotels, Hospitals, Hostels, Guest houses, Tourist bungalows, Canteen etc. on the similar lines such systems may be proved quite attractive in the process industries like paper industries.

The amount of fuel that can be saved per 100 litre capacity of hot water system for a temperature difference of 60°C using different fuels has been given in Table 2. So, a comperative analysis of the Table 1 & Table 2, clearly indicates that a large amount of energy may be saved by using non-conventional mode of energy. In an integrated system, such devices shall not only save a sufficient amount of energy, but will also enhance overall efficiency of the system. Over all our natural resources shall also be conserved.

Annexure: 1: represents the economics of power generation from the conventional power-plant of 100 MW capacity (Thermal). The cost of 1.0 KWH delivered at the pit head and at a furtherest point come out to be Rs. 2.17 and 2.46 respectively. Annexure: 2: provides the calculators for 1.0 kwh of power (thermal) received from a solar system. The cost figures out to be Rs. 0.72 per kwh. The two comparisons are made to infer that if we need 1.0 kwhr of energy from a conventional power unit and at the same time if we extract out 1.0 kwhr thermal energy from the no-conventional mode of energy, the two costs differ too much. The two figures reveal that a substantial amount of energy may be saved in this manner by incorporating non-conventional thermal in the existing systems.

Coclusion

Although there is, "nothing new under the sun", still it is highly probable that in coming future, with some technical and economic "Break through", solar energy shall be proved most reliable and approprite mode for energy conservation. Like so many other process industries, solar systems have got a vide scope in the paper industries.

References

1. J. Duffie and W. Beckman, 'Solar Energy Thermal Process,' Wiley, New York, 1974.
2. 'Solar Hot Water System,' DNES (INDIA) Publication, 1985.
3. Cost Benefit of Solar Hot Water System, study conducted by Indian Association for the Advancement of Science, Delhi, 1985.

Annexure: I

ECONOMICS OF POWER GENERATION (100 MW THERMAL UNIT)

1.0	FIXED COST (Rs.		
1.1	Investment per KW of Generating Capacity		12,000
1.2	Investment in normal Transmission and distribution (60 % of 1.1)		7,200
1.3	Additional investment for supply in remote area (same as 1.2)		7,200
		Total	26,400
2.0	GENERATION (in kwh)		
2.1	Power generation per anum (1x24x36)		8,760
2.2	Average generated power (Load Factor 50 %)		4,380
2.3	Actual Power generation (10% bus-bar losses)		3,942
2.4	Power generation after transmission losses (21%)		3,114
2.5	Coal Consumption for 4,380 kwh (0.76 kg/kwh)		3,329
3.0	COST PER kwh GENERATION		
3.1	Interest @ 1.35% on capital outlay (on 1.1.)		1,620
3.2	Depreciation @ 3.5% (on 1.1)		420
3.3	Operation and maintenance 5% 1.1)		600
		Sub-Total	2,640
3.4	Fuel charges for3,329 kg coal		
	(i) At pit head @ Rs.0.287 per kg		955
	(ii) At farthest place @ Rs. 0.55 per kg.		1,831

So,

	Cost per kwh-GENERATION	
3.4	(i) +3.4 (ii) +3.0(Sub-total)	
	(i) At pit head	3,595
	(ii) At farthest place	4,471
3.5	COST PER kwh GENERATION	
	(i) At pit head	1.15
	(ii) At distant power station	1.44
4.0	COST FOR NORMAL TRANSMISSION & DISTRIBUTION	
4.1	Interest on Capital outlay (135 % of 1.2)	972
4.2	Depreciation (3.5 % of 1.2)	252
4.3	Operation & Maintenance (5 & of 1.2)	360
		1,584
4.4	Cost per kwh transmission & distribution (4.3) - (2.4)	
		Rs. 0.51
5.0	ADDITIONAL COST OF TRANSMISSION & DISTRIBUTION	
5.1	Interest @ 13.5% on (1.3)	972
5.2	Depreciation @ 3.5% on (1.3)	252
5.3	Operation % Maintenance (@ 5% on 1.3)	360
		1,584
5.4	Cost per kwh	
6.0	TOTAL COST OF DELIVERED POWER (Rs./kwh) (e.5) +(4.4) +(5.4)	
	(i) At pit head power station	2.17
	(ii) At farthest power station	2.46

Annexure II:

COST OF SOLAR SYSTEM FOR THERMAL APPLICATION
(FOR DOMESTIC SOLAR SYSTEM)

● Electric power delivered annually by 1.0 kw of installed capacity	3,114 kwh
● Number of shiny day in a year for operation of solar system	300
● Energy per day (required)	10.38 kwh
● Heat equivalent of 10.38 kwh (1.0 kwh = k.cef)	8.927 k cal/day
● Out put from solar collector per day (7.0 kwh/day/m² with 40% efficiency)	2,400 /kcel/m²
● Collector area required for 8,927 kcal/day	3.7 m²

(This is rounded off to 4.0m²to take care of other insolation variations)

* COST ANALYSIS

-- Cost of domestic solar hot water system with 4.0 m² absorber panel along with other accessories, and, yielding 200.0 ht/day hot water at 80⁰C	Rs.10,000.00
-- Interest @ 13.5% per annum	Rs.1,350.00
-- Depreciation @ 10% per annum	Rs.1,000.00
-- Operation & maintenance @ 2% per annum	Rs. 200.00
	Rs.2,250.00

So,

Cost corresponding to 1.0 kwh	Rs.0.72