Solar water heating system

Introduction

The tanning industry uses a considerable amount of hot water during the leather production process, mainly during post-tanning operations. Until now, the industry has been heating water with fossil fuels, gas oil and natural gas, either using a conventional boiler or, in certain locations, with cogeneration.

New technologies are available for the industry to produce hot water. One option is to capture energy from the sun and convert it into thermal solar energy using a solar water heating system. In addition to generating hot water, tanneries derive other benefits including lower energy costs, reduced carbon emissions and greenhouse gases, and less reliance on fossil fuels. India is a tropical country, so its tanneries are favourably located for the application of the solar water heating systems.

Based on the experience gained from the pilot demonstration unit for solar water heating systems (PDU3) developed under UNIDO's Kanpur Leather Development Project, and similar experience gained in Bangladesh under a separate UNIDO project, this fact sheet discusses the key observations and basic considerations for implementing such systems.

Solar energy potential in Kanpur

The solar insolation data for Kanpur (Latitude 26.45 Longitude 80.332) obtained from NASA Surface meteorology and Solar Energy – Available Tables is provided below in Table 1.

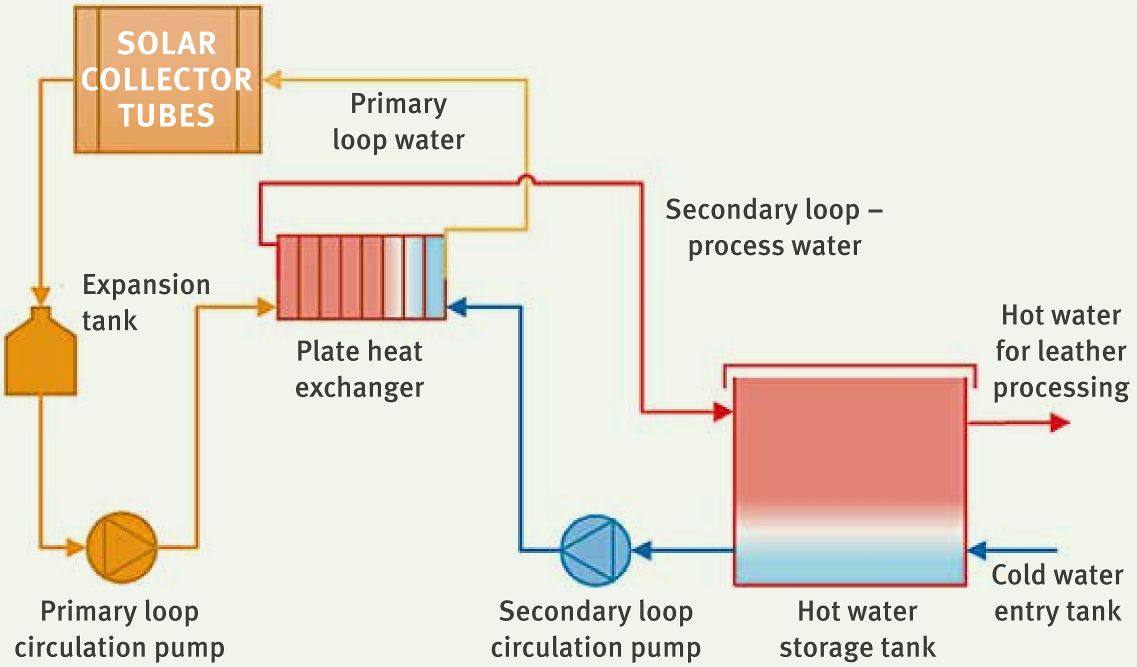
TABLE 1 **MONTHLY AVERAGED INSOLATION INCIDENT ON A HORIZONTAL SURFACE (KWH/M²/DAY) FOR KANPUR**

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
22 year average	3.72	4.67	5.75	6.32	6.57	5.91	4.8	4.48	4.51	4.87	4.26	3.6	4.95

Source: https://eosweb.larc.nasa.gov

Brief description of the system

In the primary loop, pure water is sent to the solar collectors for heating. After heating by solar irradiation, it flows to the expansion tank. This primary loop water is pumped to the plate heat exchanger where heat is transferred to the process water. The primary loop water is then sent to the solar collector tubes for further heating; thus the primary loop is a closed loop. The process water, which is kept in the hot water storage tank, is pumped to the plate heat exchanger to gain heat from closed loop water. The hot water is then circulated between plate heat exchanger and storage tank until the desired temperature is reached. This forms the secondary loop.



Main components of the system

The solar water heating system consists of the following:

1. Evacuated tube collector tubes – 40 numbers manifold, each manifold containing 30 tubes. Total occupied area: 192 m².
2. Expansion tank with a capacity of 650 litres to regulate the flow and level of water in the primary closed loop.
3. Pump for the circulation of pure water in the primary loop.
4. Tank for the make-up water (to compensate for water loss by evaporation) with a capacity of 200 litres to replenish the primary loop water.
5. Plate heat exchanger: plates are made of 316 L type stainless steel, 0.5 mm thickness.
6. Hot water storage tank with a capacity of 10,000 litres.
7. Pump to circulate water in the secondary loop.
8. Necessary valves and instrumentation such as pressure gauges and temperature probes.
9. Control panel for automatic operation of the system with an energy recorder device.

Operational data

DESCRIPTION / PARAMETER	DECEMBER 2016	MARCH 2017	APRIL 2017
Volume of hot water from the system	**2,000–3,000 litres**	**6,000–7,000 litres**	**8,000–9,000 litres**
Average temperature of the hot water from the system	**48° C**	**52° C**	**61° C**
Average time taken to heat 2,000 litres from ambient to desired temperature	**300 minutes**	**230 minutes**	**115 minutes**
Savings in coal (annualized)	**45 tonnes**		
Reduction in CO_2 emission	**115 tonnes**		

Water Hardness

If the hardness of the water is high, scaling inside the plate heat exchanger or hot water pipelines occur frequently, which needs frequent cleaning. It is necessary to operate the system at following conditions: (a) temperature of primary loop water should not go beyond 80° C and (b) the temperature difference (Δt) in secondary loop before and after heating should not be >30° C.

SCALING IN
PLATE HEAT EXCHANGER

Energy and environmental savings

The use of hot water in leather processing increases the uptake of chemicals, thereby reducing the chemical consumption. The environmental savings include a 17–30 percent reduction in chemical oxygen demand (COD) and a 6–13 percent reduction in total dissolved solids (TDS) in post-tanning operations as a result of increased uptake of chemicals.

Specific energy consumption in leather production	**54 MJ/m² of finished leather**
Hot water requirements	**7.2 litres/m² of finished leather**
Energy savings from solar hot water	**6.6 MJ/ m² of finished leather**
Savings in energy by using solar water heating system	**12 %**
Reduction in CO_2 emissions	**0.88 kg of CO_2/m² of finished leather**

Cost benefit analysis

In addition to the savings etc. in the above-mentioned cost benefit analysis, the use of hot water in post-tanning operations provides other benefits which are not quantified due to the influence of multiple factors:

(i) Use of hot water in retanning, dyeing and fat liquoring contributes to increased fixing of chemicals in leather. This provides an opportunity to reduce the quantity of these post-tanning chemicals; and

(ii) Improved quality of finished leather, particularly uniformity of shade within a piece of finished leather, as well as from piece to piece and from batch to batch.

Investment cost	**Rs. 1,700,000**
Operating cost (electricity for pumps) @ Rs.7 per kWh	**Rs. 35,000 per annum**
Cost of coal saved	**Rs. 400,000 per annum**
Cost savings in effluent treatment due to COD reduction	**Rs. 16,000 per annum**
Annual savings	**Rs. 381,000 per annum**
Payback period	**4.5 years**

THIS PILOT DEMONSTRATION UNIT HAS BEEN IMPLEMENTED BY
UNIDO KANPUR LEATHER DEVELOPMENT PROJECT,
A PROJECT OF DEPARTMENT OF INDUSTRIAL POLICY AND PROMOTION, GOVERNMENT OF INDIA.