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To Utilize Geothermal Potential for Milk Pasteurization: A Quantitative Thermodynamic Study of Geothermal Hotspot, 'Unabdeo' in Jalgaon District

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Abstract- There are many geological faults which were created during evolution of Deccan peninsula. Through these faults geothermal fluid flows. Here in SONATA (Son-Narmada-Tapti river) region near Jalgaon nearly 7 geothermal hot springs were detected in 1991 study [1]. In this paper, particularly the study of "Unabdeo" is conducted. This study focuses on the amount of energy which can be effectively utilized or can be extracted for the beneficial of local 'Adiwasi' people. The study conducted shows that the available discharge on the surface is naturally17280-69120 LPD at an average temperature of 50^0C, this study also focuses on the temperature variation with day hours, and also to check viability of this heat energy utilization for commercial use.

Key words-Unabdeo, SONATA, Efficiency, heat, cost.

I. INTRODUCTION

A hot spring is produced by the emergence of exothermally heated groundwater that rises from the crust. Water issuing from a hot spring is heated exothermally, that is, with heat produced from the Earth's mantle [6]. As we know, the temperature of rocks within the earth increases with depth. The rate of temperature increase with depth is called as the geothermal gradient. India has an estimated geothermal power potential, which is about 10,600 MW but this potential is entirely undeveloped at present [3]. The 'Geothermal Atlas of India' published by the Geological Survey of India (GSI) in 1991 describes some 340 hot spring sites and identifies more than 300 sites with geothermal potential in at least seven key geothermal provinces throughout India [2].Maharashtra government official statement was released stating that Jalgaon itself has a geothermal potential of 2000 MW[11]as this area comes under sonata region and also a geological study was conducted after the release of statement, but data was not disclosed publically. This area has natural hot springs which are perennial and the temperature was noted by officials as follows Kundawa (temp 44^0C and 25LPD),Anakdeo(44^0Cand 45LPD), Unabdeo(60^0C and 38LPD),Ramtalab(40^0C and 24LPD), Nazardev(40^0C and 16LPD) Indave(41^0C and 30LPD),Khadgaon(38^0C and 10LPD) [5].The problem associated with this locations is that it has low temperature which are usually recorded at 170 feet deep bore well and minimum temperature required for energy production is 85^0C by using binary cycle it is expected that the temperature will exceed 120^0C with 3000 meter depth of bore well [4].The temperature variations with day hours is also studied here, to check whether is there any variation's in temperature with day hours heating and cooling as in the morning the temperature of atmosphere of Unabdeo was found to be 20^0C while that in afternoon it was higher up to 32^0C; for such low temperature water which has higher Sulfur content and can be utilized for secondary applications which can be 1)To dry onion(84% moisture) 2) To dry Banana(4% moisture) 3)To pasteurize the milk 4) mushroom farming 5) egg hatching[5]. When we look at global banana production nearly 16% [6] of India's banana production is through Jalgaon and that is 3% world's production [10][8]. At the same time the most promising is milk pasteurization because of market availability in the production area itself. As that of 809000 livestock animals are there in Jalgaon district itself [9], so this locally produced milk can be pasteurized and sold to get geothermal energy benefit through it. Therefore this study mainly focuses on the milk pasteurization only. Here the counter flow heat exchanger is designed because it has maximum effectiveness and it will give us maximum output and cost effectiveness.

II. VAT MILK PASTEURIZATION

The long hold or vat pasteurization is a batch type method where the pasteurization is carried out at 63°C for 30 min. As available average temperature of water is 50^0C and also by using bore well pump, we can get 350 kg/sec water as heated input water.

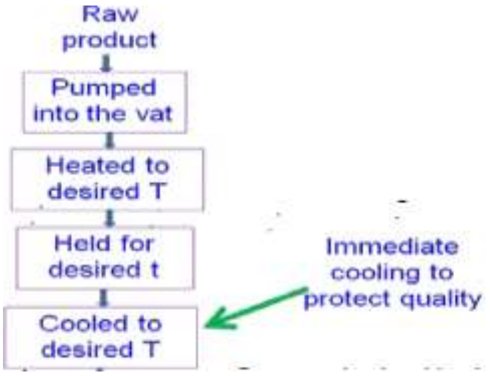

Figure II.1 VAT Process

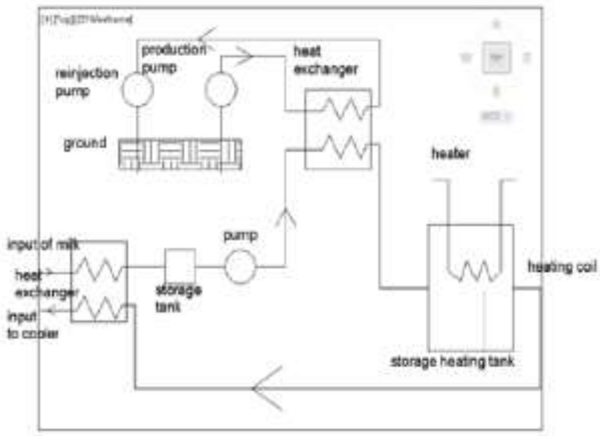

Figure II.2 Milk pasteurization plant layout

III. Location of Sites

Figure III.1 position of site 1, 2, 3, 5, 6.

Figure III.2 location of site 4

IV. Data Gathered

A. Aim

1) To identify the maximum and minimum temperature variation of geothermal fluid
2) To calculate the maximum discharge in LPD at different sites
3) To specify a certain region which will be easily accessible
4) To give list of activities which will utilize geothermal fluid
5) To give economical perspective for viability of commercial activities

B. Instrument used for studies

1) Pyrometer – digital gm. 320 infrared thermometer non-contact pyrometer IR laser point gun with backlight of range 50-380 degree ±1.5%
2) 1 liter can
3) Timer with 100millisecond accuracy

C. Procedure

1) Keep timer ready and measure the time required for 1 liter to get filled.
2) At same time measure the maximum and minimum temperature of the water.
3) From time calculate measure the discharge of water per minute.
4) Keep location of Gomukh as reference and measure the distance of site from Gomukh.

D. Temperature distribution of various sites (Appendix 1)

V. Calculations

A. To calculate the mass flow rate of fluids

Mass of milk to be processed in one day =20000Lt
Consider 2 shifts
As it is a process industry
Consider 1 shift is of 12 hours including 1 hour of rest and lunch time and 1 hour of loading milk and starting machines
Total time available =12-2=10hr
Consider I batch requires 30 minutes and 10 min loading and unloading time
Total time for 1 batch=40 min
No of batches=10*60/40=15 batches in one shift
Volume of water processed in one shift=10000Lt
Volume of milk handled by each batch=10000/15=666.67 Lt or 700Lt
Q=700Lt per batch
Mass flow rate of milk while exchanging heat =700/1800=0.389 Lt/sec
Mass of milk flow=Q*density of milk

=0.389*1034=0.402 Kg/sec

Consider the inner diameter of tube to be D1 =20mm=0.02m

$Q=3.142*0.2*0.02^2*$velocity of milk

V1=1.2378m/sec

Let outer diameter of inner tube to be D2 =24mm=0.024m

Re=density of milk*V1*D1/μ

For fresh milk the viscosity varies as μ=2.64±0.21 mPa.s

So consider average viscosity as =0.00264 Pa.s [7]

Re=9696.1>3000

Therefore it is Turbulent flow

To calculate heat transfer coefficient of inner tube side (h1)

We know from Adib &Vasseur (2008) equation for non-nucleating turbulent milk flowing in a tube we have

$h1=3.8*Re^{0.4}Pr^{0.65}$

for 1600<Re<21000 Pr lies in 1.77<Pr<5.7

By interpolating we have Pr=3.41

$h=331.6793W/M^2K$

B. To design outer tube

Crompton 150W8D10 Submersible Pump set 10 HP

Type of Product: Bore well Submersible Pump Set [12][13]

Suitable For: 150 mm Boring

Head (mm): 82-26

Discharge Range: 105-355 LPM

Consider Q=120LPM

$Density=1000Kg/m^3$

Q2=2Lt/sec

M2=2Kg/sec

Let diameter of inner side of outer tube D3=40mm=0.04m

Q2=V2*3.142*0.25*(0.04*0.04)

V2=1.5915 m/s

Re2=V2*density of water*effective diameter/viscosity of water

Effective diameter=D3-D2=0.016m

Average temp of water in outer tube=50^0C

At this temperature we have the water properties as follows

$K(50^0C)=0.6305W/m.K$

$Density=988Kg/M^3$

Pr=3.628

μ=0.0005471

$C_p=4181$ J/Kg.K

Re2=45985.07>10000

So it is a turbulent flow

Friction factor for forced flow in tube is given by Petukhov Equation

$F= (0.790lnRe2-1.64)^{-2}$

For 3000<Re<5000000

F=0.02136

Nusselt number (Nu)=

(f*Re*Pr/8)/(1.07+(12.7((f/8)^.5)(pr^0.^67-1)))

Nu=226.9495

Nu=h.D/K

$h_2=8943.23\ W/m^2K$

C. To calculate the overall heat transfer coefficient (U)

Consider tube length=200m

$A_1=3.142*.02*200=12.5664m^2$

$A_2=3.142*0.024*200=15.07965\ m^2$

$A_s=3.142*0.023*200=14.4513\ m^2$

$H_1=331.6793\ W/m^2K$

$h_2=8943.23\ W/m^2K$

Consider, the inner tube made of aluminum having K=237.46 W/m.K

Fouling factor for both inner and outer surfaces to be =

$F_0=F_1=0.0001$

$(1/(UA_s))=(1/(h_1A_1))+(1/(h2A2))+(F_1/A_1)+(F_2/A_2)+(ln(D_2/D_1)/(2*3.142*L*K)$

$U=263.9386\ W/m^2K$

$NTU=UA_s/C_{min}$

$C_{water}=2*4182=8364$ KJ/K

$C_{milk}=0.402*3920=1575.84$ KJ/K

$C_{milk}< C_{water}$

$C_{min}=1575.84$ KJ/K

$C= (C_{min}/C_{max})=0.1884$

NTU=2.42045

For counter flow heat exchanger

ε=(1-exp(-NTU*(1-C))/(1-C exp(-NTU*(1-C))

ε=0.8830919

$ε=(T_{co}-T_{ci})/(T_{hi}-T_{ci})$

$T_{co}=47.07^0C$

$T_{ho}=45.840^0C$

$T_{Lm}=T_{in}-T_{out}/\ (ln\ (T_{in}/T_{out})\ =9.1290^0Ct$

D. Revenue generated

$Heat\ rate=Cmin*(T_{co}-T_{ci})=34.794KW$

Time=54000 seconds

Energy saved per month =54000*34.794*30=56366280 KJ

Electricity bill for small scale industry for 1 KWHr is 8.43 Rs.

Money saved=15657.3 INR per month

Per year it will save=1583892.468 INR.

Return on Investment=5 months.

VI. CONCLUSION

"Unabdeo" field has perennial water flow and maximum temperature of water was found to be 50^0C and water flow with pump was calculated to be 120LPM. The discharge of water was varying from position 1 to6 as per the technology used and at some sites it was natural so variation in discharge was from 2-240 LPD. Here some part of study was done in forest reserve area and some part was studied outside of forest reserve area and the total area covered was 1 km^2 and as per officials say it was nearly 1 km2 where geothermal potential exist. Further study can be conducted to study viability of drying banana and onion which has great potential supplier market in Jalgaon. Using heat exchanger we can save up to 15 lacks per annum .Jalgaon district has enormous potential of geothermal resources that has to be properly utilized and not only that the presence of abundance of solar energy can be utilize in hybridization with geothermal energy to boost the regional industry such as banana drying and onion drying.

VII. REFERENCES

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Appendix 1

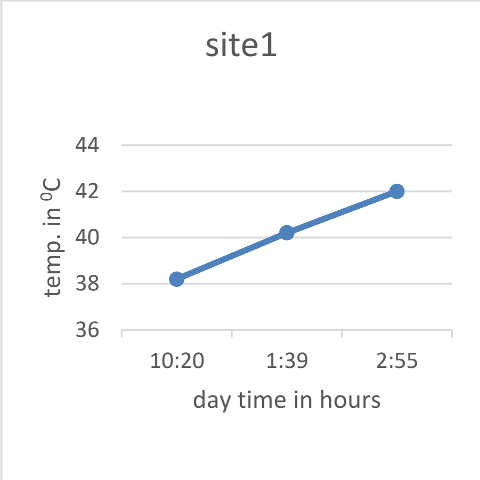

Figure VII.1 Temperature Distribution of Site 1

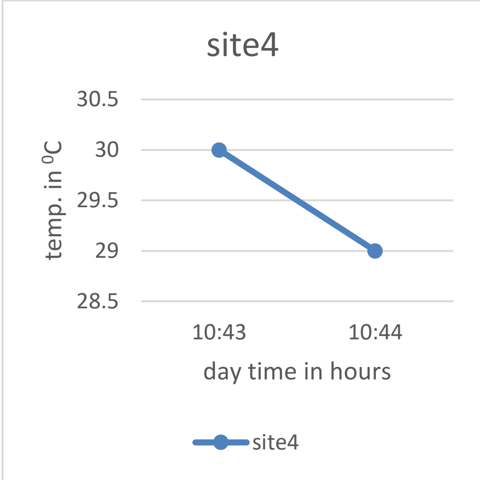

Figure VII.4 Temperature Distribution of Site 4

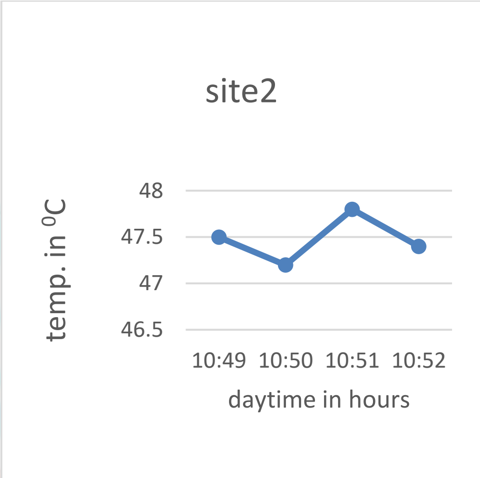

Figure VII.2 Temperature Distribution of Site 2

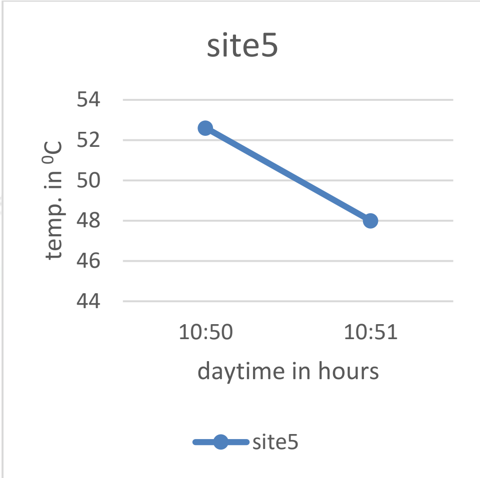

Figure VII.5 Temperature Distribution of Site 5

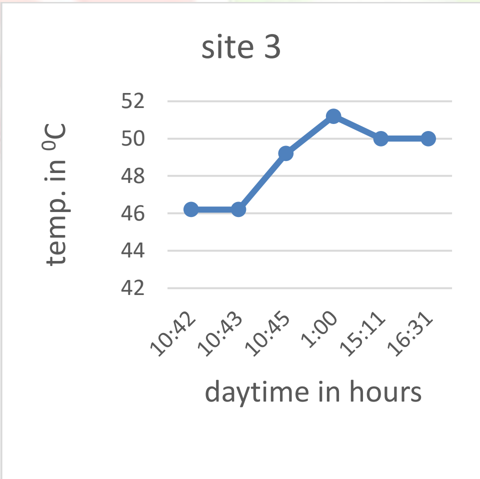

Figure VII.3 Temperature Distribution of Site 3

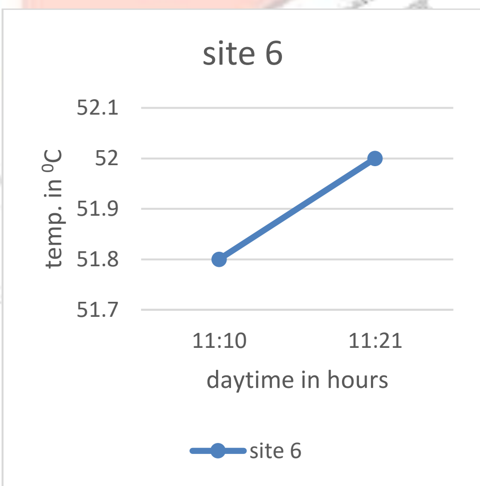

Figure VII.6 Temperature Distribution of Site 6

Graphs of various sites and there temperature variation with daytime in hours, respectively of site 1 to 6

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