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Investigations on Parabolic Collectors: A Review

TVR Sekhar

PhD Student, Amity University, Noida, UP, India

Abstract: **Parabolic collectors are widely used for concentrating solar energy for thermal applications. Researchers have conducted experiments to enhance efficiency of the collectors by employing several methods and simulation techniques. A review of the investigations and future scope of investigations on parabolic collectors is presented.**

Keywords: **Concentrator, Parabolic trough, Receiver, Solar collector, solar trough.**

I. INTRODUCTION

The emergence of solar collectors in the field of renewable energy has raised hopes for the availability of affordable and sustainable energy across the world. Although photovoltaic panels are presently being used for small and medium scale energy requirements, their use in a larger scale has limitations considering the silica pollution and the disposal of battery banks. Solar collectors are an alternative when it comes to large scale sustainable use of solar energy for mankind. Parabolic collectors are devices which concentrate incident solar radiation onto a working fluid which rapidly gains temperature for use in thermal applications. Researchers have conducted several experiments on parabolic collectors to investigate the enhancement of thermal properties of the collectors & the working fluids used in them. Scott A. Jones et al [8] investigated on a parabolic trough plant .A30MWe parabolic trough plant was created in the simulation environment. Good agreement between model predictions and plant measurements was found. The field of large to very large scale use of parabolic solar collectors holds promise for the energy sector in the near future.

II. PARABOLIC TROUGH COLLECTORS

Unlike flat plate solar collectors, the parabolic collectors shape like a parabola and concentrate the incident solar energy at the centre of the parabola where a conducting metal pipe is mounted in the longitudinal axis. The concentrated heat energy is transferred to a working fluid, in most of the cases it is water. Parabolic trough collectors are again of two sub types, Stationary and tracking type collectors. The stationary collectors are seasonally kept in a particular alignment to receive the solar radiation. The tracking collectors consist of tracking mechanisms which track the suns movement and accordingly align the collector. The tracking collectors are of course more efficient than the stationary type as the quantum of radiation energy received per daylight session is much more than the non tracking ones.

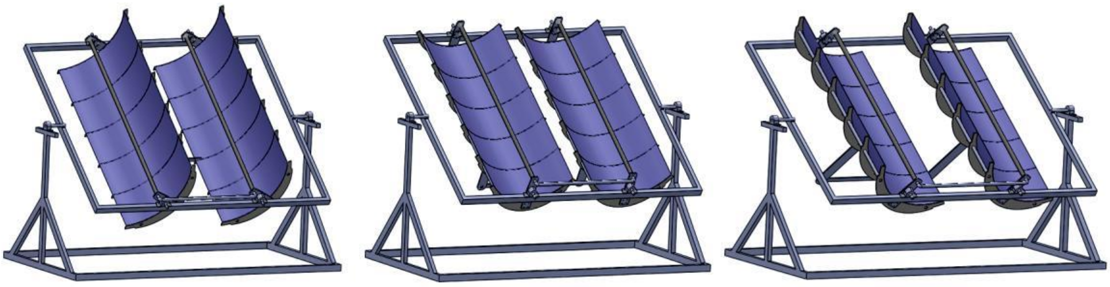

Fig 1: Solar Parabolic Trough Collector,[1]

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III. INVESTIGATIONS ON PARABOILC TROUGH COLLECTORS

Investigations in Parabolic collectors are based on the application of the collector, the geographic region of usage and the utility where it is used i.e either domestic use of industrial use. Investigations are carried out by making changes in the physical dimensions of the collector. Ganime Tugba Ercoskun et al [1] devised a double grooved parabolic trough type collector. In this study, parabolic solar collector with 90cm collector aperture and 83 degrees rim angle was designed. In order to reduce heat losses in the system, receiver pipe and glass tube is placed coaxially. In this investigation, air between the two pipes vacuum were evacuated. In the designed parabolic collector, two-axis solar tracking system is used. Performance tests in which water was used as the heat transfer fluid were conducted in the climatic conditions of Tarsus.

Fig 2: Parabolic trough-type solar collector,[1]

K. S. Reddy et al [2] investigated on a solar parabolic trough concentrator. In this study, Various porous receiver geometries are considered for the performance evaluation of the solar parabolic trough concentrator. Geometries such as fin aspect ratio, thickness, and porosity, for different heat flux conditions are measured and comparison is made. Results show that the minimum and maximum measured efficiency values of the system are 37.59 % and 50.60 %.The study also reveals the average efficiency of the parabolic concentrator as 43.03 %.

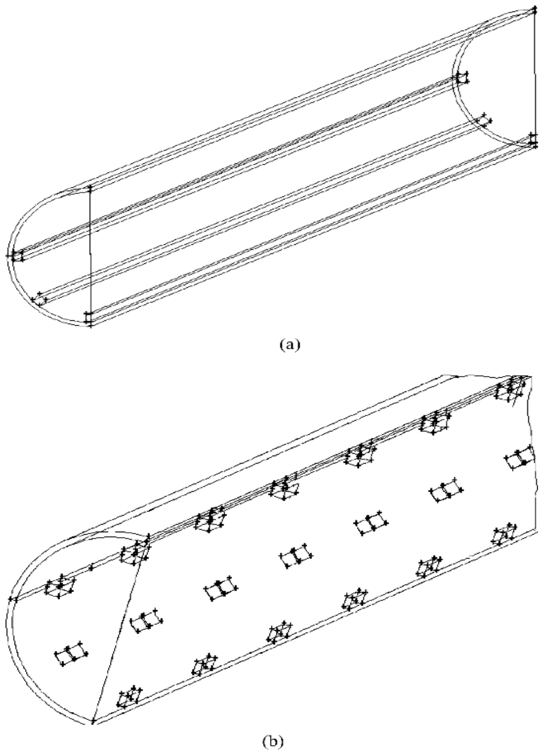

Fig 3: Physical model of solar parabolic trough receiver: (a) longitudinal, (b)]Porous fins,[2]

Z. Baniamerian et al[3], investigated on parabolic solar troughs using CFD(Computational Fluid Dynamics) methods. The variations of aerodynamic coefficients considering terrain effects, the angle of collectors and the gap between mirrors have been studied. Also, the results demonstrated that in order to properly align trough collector in solar farms, it is essential to study the vortices shed created at the behind of parabolic troughs and its effects on collector's structures in the result of wind interaction. Numerical results for the drag and lift coefficients of collectors have also been calculated in this investigation.

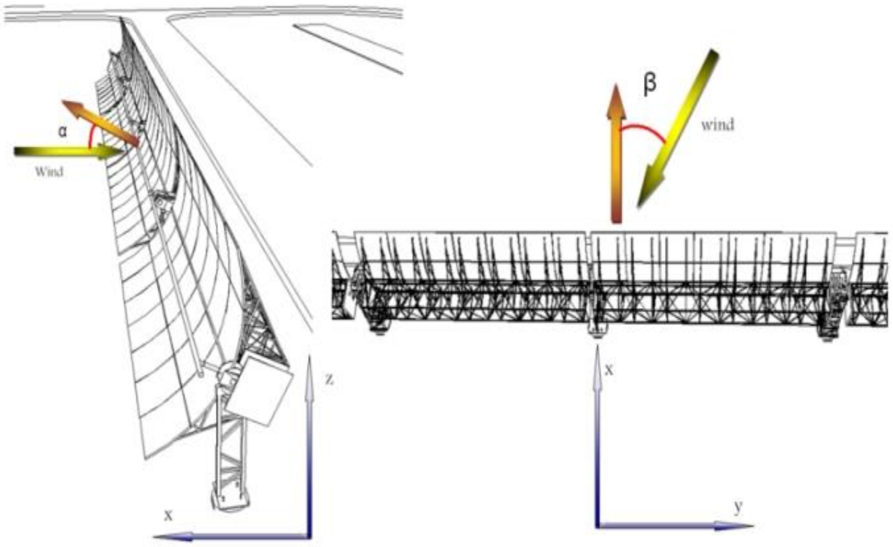

Fig 4: Schematic with aerodynamic angles, [3]

M. Ebrahim Ali Alfegi et al[4] studied a hybrid photovoltaic and Parabolic collector set up. An experimental investigation of solar air heater with photovoltaic cell located at the absorber with compound parabolic collector (CPC) and fins is conducted. The performance of the photovoltaic, thermal and combined PV/T collector over a range of operating conditions is studied . Results at solar irradiance of 400 W/m2 showed that the combined PV/T efficiency is increasing from 27.50% to 40.044 % as mass flow rates varies from 0.0316 to 0.09 kg/ s.

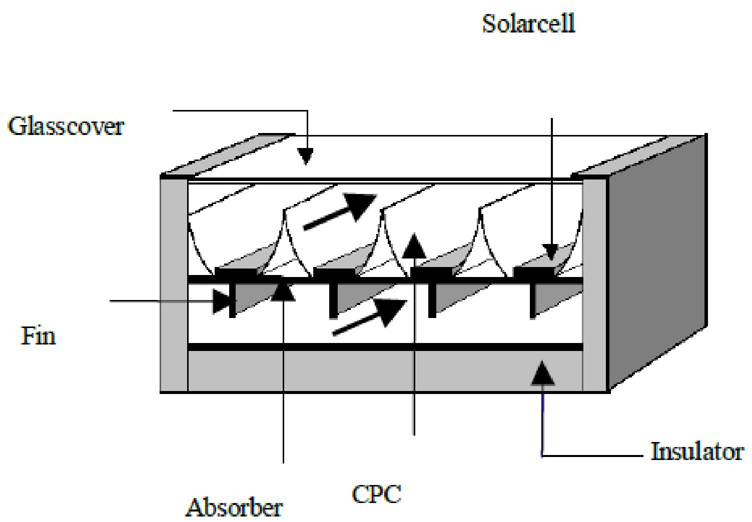

Fig 5 :The schematic model of Single pass, double duct (PV/T) solar collector with CPC and fins,[4]

J. Selvaraj and V. Harikesavan [5] conducted experiments on parabolic troughs. The experiments were conducted on aluminium raw materials of various thicknesses under different times in a day to measure the energy absorbed by the raw materials .It was observed that of temperature rise as high as 106 ºC could be achieved by this method. The results point

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to energy savings of 6.77 % of the total energy required for melting the scrap.

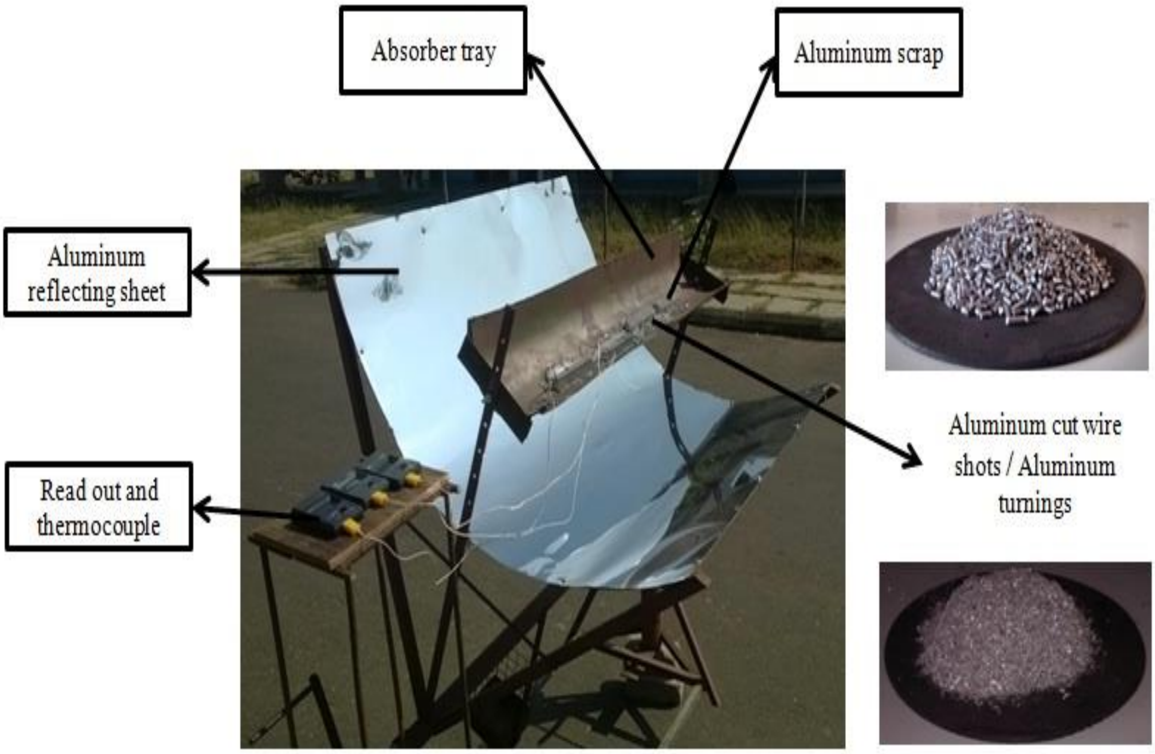

Fig 6: Improvised experimental setup with heat transfer enhancers,[5]

K. S. Chaudhari et al [6] investigated on the efficiency of a parabolic trough solar collector experimentally using the working fluid as Al2O3 + water nanofluid . The weight fraction of nano particles was 0.1% and the particles dimension was 40 nm. Experiments were performed with and without nanofluid. The mass flow rate of nanofluid was kept constant at 2 Lit/min .From the results, it was concluded that the nanofluid causes an enhancement in heat transfer coefficient by 32%. The investigations also comprises of the preparation of nanofluid, calculation of nanofluids properties, test results tabulation and performance evaluation of Parabolic Trough Solar Collectors with and without nanofluids.A summary of the investigations conducted on parabolic trough collectors is given below.

TABLE: I Summary of Investigations carried out on Parabolic Collectors

Paper Reference	Investigators	Collector Type	Experimental set up	Findings
[1]	Ganime Tugba Ercoskun et al	Double grooved parabolic trough type solar collector	Parabolic solar collector with 90cm collector aperture and 83 degree Rim angle and consisting of double parabolic trough was designed. In the designed parabolic collector, two-axis solar tracking system is used.	Minimum and maximum measured efficiency values of the system are 37.59 % and 50.60 % and the average efficiency is 43.03 %.
[2]	K. S. Reddy et al	Solar parabolic trough concentrator	Various porous receiver geometries are considered for the performance evaluation of a solar parabolic trough	The inclusion of porous inserts in tubular receiver of solar trough concentrator enhanced the heat transfer about 17.5% with a pressure penalty of 2kPa.

			concentrator.	
[3]	Z. Baniamerian et al	Parabolic solar troughs	Investigated using CFD methods	The variations of aerodynamic coefficients have been studied. Also, it is demonstrated that in order to properly align trough collector in solar farms, it is essential to study the vortices shed created at the behind of parabolic troughs and its effects on collectors' structures in the result of wind interaction. The drag and lift coefficients of collectors have also been calculated in the study.
[4]	M. Ebrahim Ali Alfegi	Hybrid set up of Photovoltaic and Parabolic collector.	Solar air heater with photovoltaic cell located at the absorber with compound parabolic collector (CPC)and fins.	The performance of the photovoltaic, thermal and combined PV/T collector over range of operating conditions and the results was discussed. Results at solar irradiance of 400 W/m2 showed that the combined pv/t efficiency is increasing from 27.50% to 40.044 % at mass flow rates variations from 0.0316 to 0.09 kg /s.
[5]	J. Selvaraj,V. Harikesavan	Parabolic troughs	The experiments were conducted on aluminium raw materials of various thicknesses under different times in a day to measure the energy absorbed by the raw materials.	As high as 106 ºC of temperature rise could be achieved by this method. Results point to energy savings of 6.77 % of the total energy required for melting the scrap.
[6]	K. S. Chaudhari et al	Parabolic trough solar collector	Parabolic trough solar collector with Al2O3 + water nanofluid is used .Weight fraction of nano particles was 0.1% and the particles dimension was 40 nm. Experiments were performed with and without nanofluid. The mass flow rate of nanofluid is kept constant at 2 Lit/min.	Nanofluid causes an enhancement in heat transfer coefficient by 32%. The the preparation of nanofluid, calculation of nanofluids properties, test result tabulation is conducted. Performance evaluation of Parabolic Trough Solar Collectors with and without nanofluids is compared.
[7]	K. Syed Jafar, B. Sivaraman	Solar parabolic trough collector	An absorber with twisted tape in solar parabolic trough collector to obtain optimum process parameters by Statistical tools such as design of experiments.	Significant increase in Nusselt number and considerable friction factor is obtained at high Reynolds number and low twist ratios parameters. Results point to the twist ratio as the major parameter that influences absorber of parabolic trough collector performance.
[8]	Scott A. Jones	Parabolic trough plant	30 MWe SEGS VI parabolic trough plant was created in the TRNSYS simulation environment .	Good agreement between model predictions and plant measurements was found, with errors usually less than10%. Also, transient effects such as startup, shut down and cloud response were adequately modeled.

K. Syed Jafar and B. Sivaraman [7] carried out a study on solar parabolic trough collector consisting of an absorber with

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twisted tape to obtain optimum process parameters by Statistical tools such as design of experiments. In the study,parameters as Reynolds number and twist ratio are optimized with the consideration of responses as the heat transfer and friction factor.It was observed that there is significant increase and augmentation in Nusselt number .Results showed that considerable friction factor can be obtained at high Reynolds number and low twist ratios parameters. Results also pointed to the twist ratio as being the major parameter that influences absorber of parabolic trough collector performance.

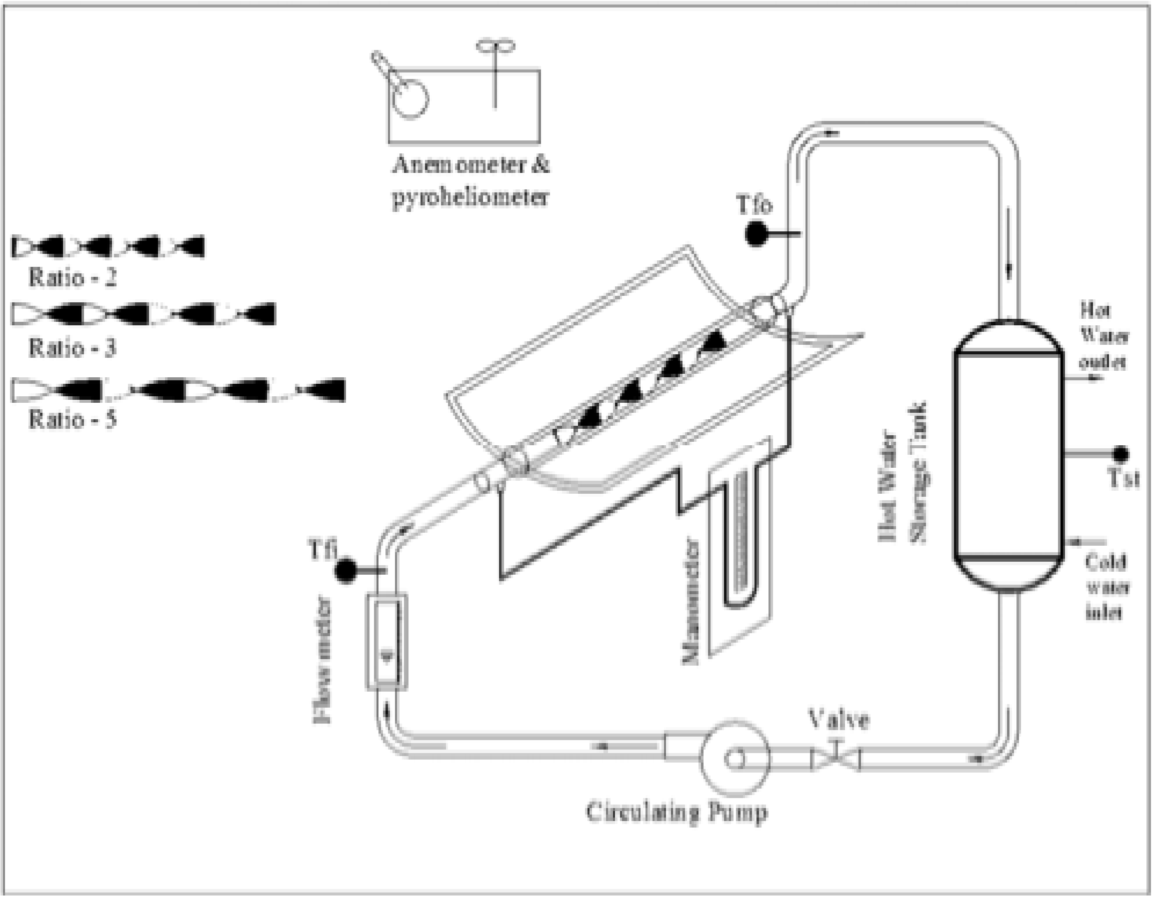

Fig 7: The schematic diagram of experimental setup,[7]

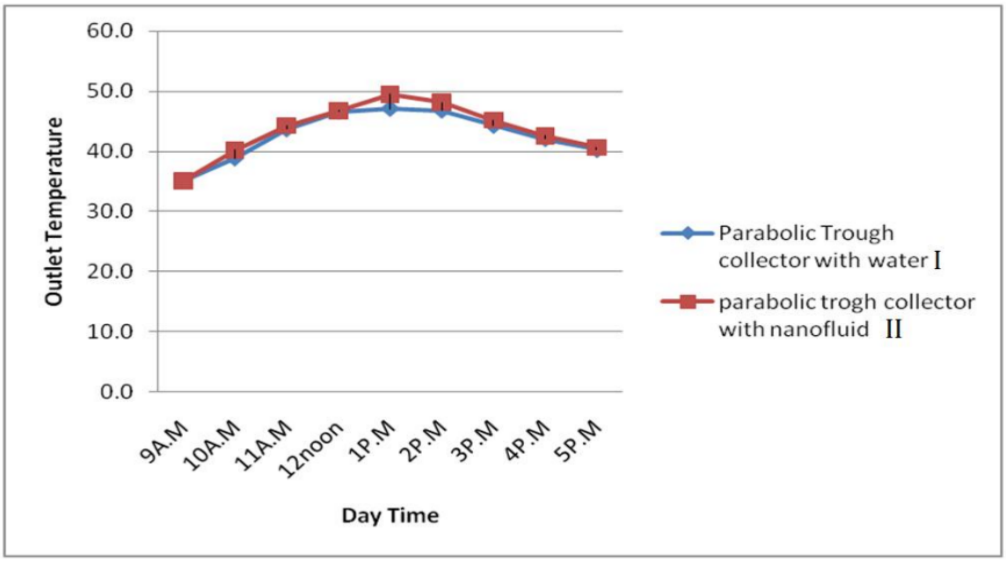

Fig 8: Variation of temperature in periods of day time, [6]

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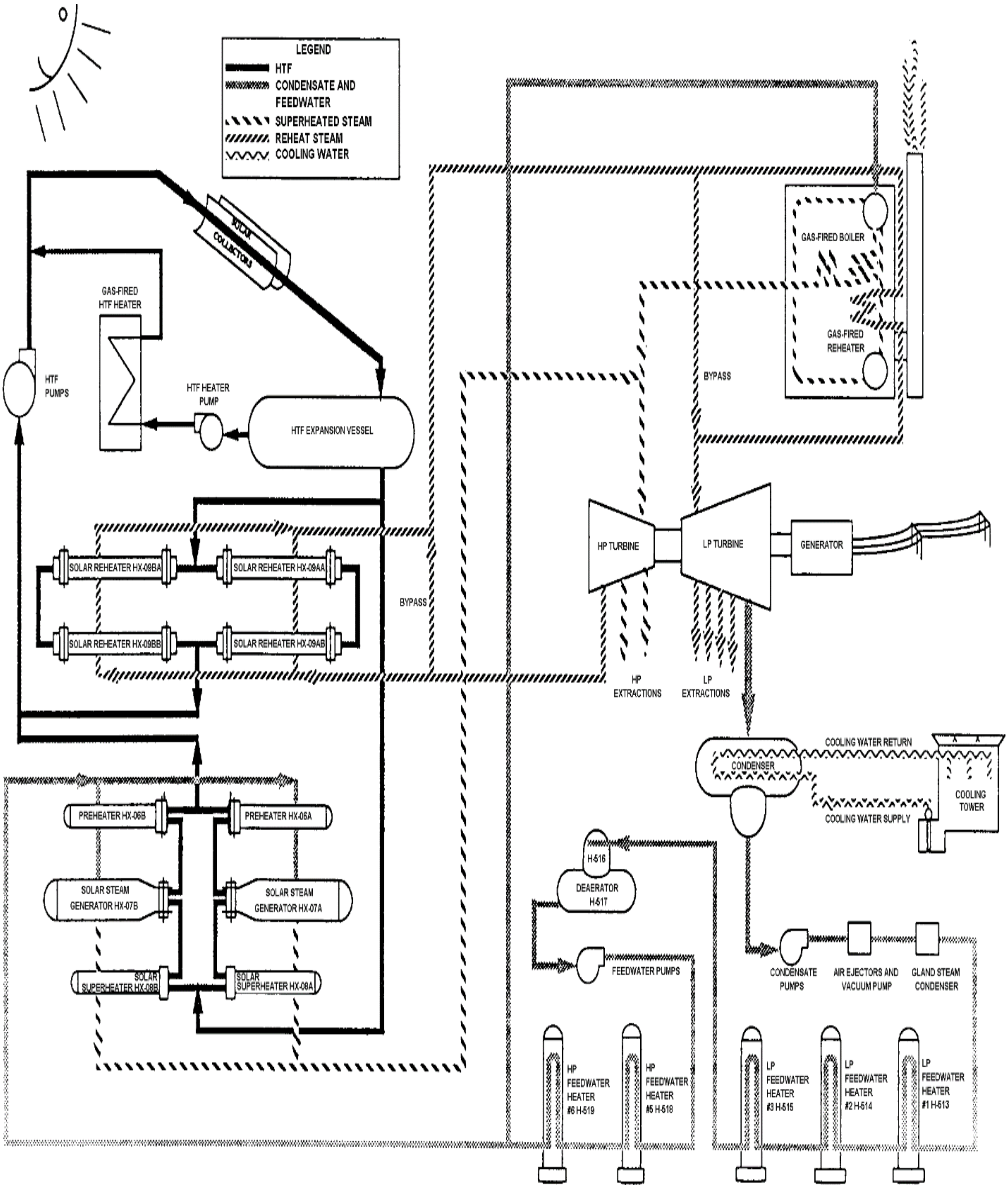

Fig 9: Schematic of the SEGS VI plant,[8]

IV. CONCLUSION

Parabolic collectors are a subject of active research. They are investigated upon by several researchers by modifying the aspects of the collectors and by making minor changes in the collector set up. Researchers are employing the use of hybrid collectors like PV/T systems to enhance efficiency. Also, studies are being conducted to indirectly harness the thermal energy for preheating purposes for considerable energy savings in the industry. Various statistical tools are employed and simulation models are being developed in the line of large scale use of parabolic trough power plants. Advanced research and modeling with the help of computational Fluid Dynamics for enhancing the performance of the

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parabolic collectors is under way to provide with futuristic collectors. A more recent of use of nanofluids in the place of conventional working fluid is gaining momentum in the studies related to parabolic collectors . There is a vast scope for the study in the emerging field of hybrid nanofluids and their use as working fluids in the Parabolic trough collectors, which are becoming the mainstay in the thermal generation for years to come.

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