A Mini Review of Solar Air Heater Modifications to Improve the Performance

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Abstract:

Because solar air heaters are considered one of the most important devices, it may be possible to increase or increase the temperature that can be used in houses and buildings. Solar air heaters are used worldwide. Solar Air heaters are very cheap and easy to fabricate because they require skilled labor. Recently, several researchers have attempted to improve the thermal efficiency of solar air heater, which are presented in this review article. The work, future scope, and problems faced when working on the solar air heater have also been included for the benefit of future researchers.

Keywords: Solar air heater; Thermal efficiency; Solar Energy

Introduction:

During the search for energy-saving or environment-friendly solutions, solar–air heater technology is a great option that can provide heat in a more livable manner and provide a comfortable natural atmosphere. It is a way to be sustainable with sun rays, alright for everyone at home, and even businesses. Solar air heaters have attracted considerable attention because they are easy to use and cost-effective, and there is an increasing interest in the reduction of environmental effects caused by conventional heating systems based on fossil fuels [1]. Owing to their low capacity, solar–air heaters are used in small-scale space heating, as well as the process heat required by various industries with direct or indirect gain [2]. They are ideal for use in housing, agriculture, and industry to reduce energy consumption in homes or businesses, as they have quick set up options that silicone provides long-term solutions instead of traditional heating methods. Continued efforts are aimed at improving these, and the purpose of this work is to summarize findings from recent investigations and suggest directions for future investigations [3].

Research works on solar air heater (SAH)

Venkatesh et al. [4] made a significant contribution by Tiwari et al. carried out work to improve the thermal performance in terms of heat transfer fluid (air) and absorber modification for SAH. The work focuses on comparing a common absorber (SAH-1) with an improved setup using rectangular fins (case SAH-2), and another one making use of phase change materials based on sodium carbonate decahydrate – $Na_2CO_3·10H_2O$, magnesium sulfate heptahydrate -$MgSO_4·7H_2O$, in the presence of fins too. The refined PCM-finned (SAH-3) with airflow at rates of 0.042 and 0.059 kg/s showed a favorable operation, collecting heat power up to Q H =927,32 W e recording an impressive thermal efficiency GP=78,9%,

Antonio and Antonio [5] developed an outstanding solar thermal system where 180 °C to 350°C hot air was directly supplied for industrial heating using linear Fresnel collectors without the use of a liquid as heat transfer fluid. Therefore, ease of installation is a high priority and the technology must be lower than that of other solar technologies.

The work described herein is motivated by the lack of reference studies and analyses that can predict real behavior in an energetic and economic manner, but also to theoretically assess a concentrating solar air heater from medium-scale benchmark cases with representative European conditions. These outcomes show that the solar technology carrying on this paper is expected to be a competitive alternative compared with conventional natural gas heating, you have an enormous chance as source of replacement for amino acids fossil fuels in commercial hot air applications.

Salarpour and Azadani [6] presented an experimental investigation on the thermo-hydrodynamic characteristics of a solar air heater channel equipped with six types of roughness elements (inline, staggered, rectangular, and square ribs with V-shaped baffles or ribs). The design parameters for each geometry were optimized, and the thermohydraulic performance was compared across heaters with these optimal designs. A full factorial design of experiments was used, and 25 numerical experiments were conducted with THPP as an objective function.

Pal et al. [7] studied the novel use of conical jet impingement with sine-wave corrugation over solar air heater absorber plates to augment heat transfer. The target wave amplitude ratio (0.079–0.314), throat jet diameter ratio (0.063–0141), base jet diameter ratio (12 6 -025) and Reynolds number from 320 to approximately two hundred thousand. The Reynolds-averaged Navier–Stokes equations were resolved by computational fluid dynamics simulations based on an RNG k–ε turbulence model, which was verified in comparison with the corresponding experiments. The results reveal an appreciable enhancement in heat transfer with a Nusselt number of 6.71 times and the friction factor rising about 13.87 times compared to solar air heaters with smooth surface configurations.

Vyas et al. [8] investigated the thermohydraulic performance of a double-pass solar air heater (DPSAH) with its bottom plate roughened by using AEROFOIL fins. CFD analysis RAJENDRAN et al. developed and validated a DPSAH model that takes into account the influence of different types of fins, variation in solar radiation during diurnal time period absorber plate material properties absorption rate factor flow conditions at relative height ratio (h/H) ranges from 0.17–0.50 with respect to l=3 m for fin length, along we find passage channel width as DO=.22H and also fixed the value of MPS =5%. An increase of 4.23 times in the relative Nusselt number and an improvement of 2.51-fold were found at Re =3000 using the RNG k-ε turbulence model.

Bhuvad et al. [9] performed a discrete heat transfer analysis to evaluate the energy–exergy and economic-environmental performance of a SAH with apex-down arc-shaped ribs on a roughened plate. Gap width to rib height, relative rib height and pitch to hegiht ratios are 4, 0.045,10 respectively; three separate test cases angle which the arc starts from is analyzed where as discussed below: Between 70 and 80% loss of the exergy to environment was seen, while a maximum system-to-air exergy lost at value Reynolds =3000) amounted to over 5.64 W The maximum thermal and exergetic efficiencies were 77.60% (at T = 500 °C) and eWIT, out=3.81 % (T =450. Under optimal conditions, the apex-down ribs had a shorter energy payback time and higher net annual energy yield than plain surfaces (+ 3.7% in EPBT value) with a angle of rib at 30°.

Almeshall et al.[10] used conical rings situated strategically between the fins on an absorber plate in an impingement jet solar air heater (SAH) improve the thermal performance as [10] Fig. The present analytical work was carried out to find the optimal geometric parameters: ring thickness ratio (TR/DH) between 0.07 and 0.13, diameter-to-thickness ratio of the rings (Do/TR), with four different spanwise pitches for fins corresponding to Y/Do values ranging from almost inline arrangement at a distance of approximately pitch inversion all the way up to infinite interval, which means there are no fins in this transonic ducted fan engine application). In this study, MATLAB simulations validated the new supersonic jet impingement design to achieve maximum energy and thermohydraulic efficiencies of 81.4% and 777%, respectively.

Problems faced by researchers

Challenges faced by researchers of solar air heater technology Researchers working on the development of Solar Air Heater technology face several challenges that can hamper their research and restrict the effectiveness of this system. While the power available from a satellite is nearly unlimited compared to that of an aircraft, the fact remains its limited ability to convert solar radiation into useful electrical signals → solar→ depends strongly on geographical position, time of day or year, and weather conditions. The abovementioned variation in solar energy can also lead to fluctuations in the performance of a solar air heater to, resulting in various heating outputs, which makes it challenging to obtain a fixed heating output. Second, the design and materials of the solar collector must be optimized. Thermal considerations, such as the heat transferred that must occur and the insulation needed for energy efficiency, are often met with compromise to find optimal materials in terms of conductance properties (e.g., airflow is undesirable) versus durability characteristics or cost-effective solutions given competing requirements between thermal efficiency and length prospective use time frame regarding life cycle vs. first cots issues that require a certain level end quality control process be performed before release onto their respective market.

A major problem is how supplementary air heaters can be integrated into an established heating system. However, this involves the challenges of how these systems can fit well within existing legacy infrastructures that often require an overhaul to accommodate such solutions. This integration also requires the interdisciplinary work of engineers, architects, and politicians to build solutions that work through practice and are coherent and economical. In addition, long-term performance testing, which is an important task for researchers, is not feasible owing to the changing environment and usage patterns. Therefore, the development of a systematic approach to determine credible performance specifications and benchmarks for innovative air heaters is paramount to enhancing their adoption in the residential and commercial sectors.

Future Scope:

The future prospects of solar air heaters seem brighter than ever before, since renewable energy sources are expected to be increasingly in demand in the near future. One notable area of progress has been boosting efficiency through special materials and technologies. This can be further optimized with advances in thermoelectric materials, nanotechnology, and phase change materials to increase heat absorption and retention, resulting in better performance of solar air heaters. They are also investigating selective coatings that can enhance solar absorbance while reducing heat loss, which would substantially improve energy conversion efficiency.

Furthermore, utilizing air heaters with advanced technologies provides an attractive option. This facilitates continuous system performance monitoring and optimization through smart controls/automation, which not only elevates the user experience but also energy efficiency. Solar air heaters can be tied into smart homes and buildings through Internet of Things (IoT) devices for lower energy usage at the macro level.

Another prospective trend might bring about a revolution in the application of SAHs in different fields. Beyond creating a warm environment in people’s homes, these systems could also be used for larger commercial buildings, industrial processes, and other kinds of agricultural applications (e.g., crop dryers or greenhouse heating). This versatility gives them the possibility of finding acceptance and unlocking energy savings in various sectors.

That said, policy support and incentives could be decisive in shaping the growth trends applicable to air heaters. International governments have begun to work more on green technologies that offer financial incentives. This system-level support should excite research and development worldwide, eventually resulting in the widespread dissemination of solar air heater technology as a component of global energy systems.

Conclusion:

- A solar–air heater is one of the best ways to use renewable energy technology, which provides considerable contribution and a remarkable solution for heating by eco-friendly requirements. Solar air heaters are a green alternative for the world, moving away from fossil fuels and towards renewable. This is critical to combat climate change and appears inescapable of burning, which is another part of the heating retainer cost.
- The other main factor in the popularity of solar air heaters is that they are quite versatile. It can be used in many applications, from heating a home to powering industrial processes and farming practices.
- Furthermore, new research and developments might enhance solar air heater efficiency. Performance and usability are expected to see jumps from upgrades in materials, design, and integration with smart technology, which will make them more capable of overcoming shortcomings and increasing their scope.
- Supportive policy framework and government incentives will be another key driver to support the movement in solar air heaters adoption across countries. Policymakers could incentivize households and businesses to invest in solar-heating solutions by encouraging renewable energy projects with financial support.
- There will always be a bright future for air solar heaters, with an increased possibility of advancement. The widespread adoption of solar air heaters is one of our best shots of a sustainable energy future if done right by taking advantage of renewable resources, improving upon efficiencies, and last but not the least supported, furthermore, with accessibility through relevant policies.

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