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Recent progress on renewable energy in engineering thermophysics

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This article portrays a concise review on the state-of-the-art advancements in methodologies and applications of engineering thermophysics for renewable energy, which includes wind energy, solar energy, geothermal energy, biomass energy, hydroelectric energy and CO_2 capture, transportation and storage.

renewable energy, engineering thermophysics, recent progress

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In the past two years, great progresses have been made in the field of renewable energy [1–3]. The corresponding important progress of various energy utilizations will be reviewed, including wind power, solar energy, biomass, geothermal energy, and so on.

1 Wind energy

In the field of wind energy, the scientists and engineers have mainly focused on aerodynamic performance, low noise, and the control of wind turbine and its components [4–16]. Yang et al. [4–6] developed a model of delta-wing type vortex generator. Based on this, the aerodynamic controls of a wind turbine airfoil and a blunt trailing-edge airfoil were investigated. Zhang et al. [7,8] conducted experimental investigations on a passive wall vibration control using a uniform bubble cloud and an active control of the blade-vortex interaction (BVI) noise, frequently seen in rotating turbines using a novel perturbation technique. Kim et al. [9] demonstrated an effective noise control using a newly developed airfoil on a 10 kW class wind turbine, laying a foundation on the commercial utilization of full-scale tubines. Wata et al. [10] analyzed a new low-Reynolds number airfoil created for small wind turbines. Liu et al. [11] have treated the aerodynamic performance of a micro downwind rotor with coning soft blades.

2 Geothermal energy

In the field of geothermal energy [17–27], Song et al. [21] represented the heating performance of a water-to-refrigerant type ground source heat pump system. Lee et al. [22,23] evaluated the thermal conductivity and the viscosity of bentonite grouts have been evaluated and compared with each other to determine the suitability of these materials for backfilling vertical boreholes of ground heat exchangers. Guo et al. [24] carried out a comparative analysis on CO_2-based transcritical Rankine cycle and HFC245fa-based subcritical organic Rankine cycle using low-temperature geothermal source, and they also investigated a novel combined power and heat generation system. Park et al. [25] considered the applicability of cement grout (or cement-based grout) as an alternative to bentonite grout commonly used to backfill closed-loop vertical ground heat exchangers. Choi et al. [26] carried out a series of numerical analyses in order to evaluate the performance of full-scale closed-loop vertical ground heat exchangers constructed in Wonju, South Korea. Yu et al. [27] presented a novel electrohydrodynamic

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(EHD) micropump based on MEMS technology.

3 Solar energy

In the field of solar energy domain [28–44], many researches have focused on solar thermal applications. For example, Liu et al. [33] carried out the experimental investigation on a parabolic trough solar collector for thermal power generation. Xiong et al. [34] developed a two-dimensional empirical model to investigate the thermal performance of heat loss of parabolic trough receivers under steady state equilibrium. Hou et al. [35] carried out the evaluation of solar aided biomass power generation systems with parabolic trough field. Refs. [36,37] proposed a newly designed solar collector, so-called dual-function solar collector. Chen et al. [38,39] experimentally investigated several kinds of high temperature molten salts on viscosity-temperature characteristics with high-temperature viscometer, as well as the effect of a dual-function solar collector integrated with building on the cooling load of building in summer. Other aspects of important progress have also been made, e.g. solar cell [40–43] and photocatalytic degradation [44].

4 Biomass energy

In the field of biomass [45–64], Luo et al. [50] estimated the annual generation of crop residues, animal manure and organic faction of MSW in Hebei Province, China from 2002 to 2007. Qiao et al. [51] investigated the biogas recovery from microwave heated sludge by anaerobic digestion. Li et al. [52] reviewed the progress and recent trend in MILD combustion. Other relative fundamental researches such as combustion can be found in [53–64].

5 Hydroelectric energy

In the field of hydroelectric generating, the typical researches are reviewed as follows. Zullah et al. [65] presented the results of a computational fluid dynamics (CFD) analysis of the effect of blade configuration on the performance of two Savonius rotors for wave energy extraction. Prasad et al. [66] analyzed the effect of front guide nozzle shape on the flow characteristics in an augmentation channel of a direct drive turbine for wave power generation. Shimokawa et al. [67] studied the side-wall effect of runner casing on the performance of Darrieus-type hydro turbine with inlet nozzle for extra-low head utilization. Wang et al. [68] summarizes the internal and external factors affecting stable operation of a hydroturbine and described the methodology for partitioning the operating region and its engineering importance through the examples of the Francis turbine unit at the Wanjiazhai Hydropower Plant and the Kaplan turbine unit at the Shuikou Hydropower Plant. Zeng et al. [69] presented the result and analysis of the composition of energy loss occurring in the hydro turbine. Jo et al. [70] reviewed the recent TCP (tidal current power) projects in Korea.

6 CO_2 capture, transportation and storage

For the field of CO_2 capture, transportation and storage [71–77], Gao et al. [74] proposed a possible energy network with polygeneration system and CCS technique in China. Sakaguchi [75] gave a solution of best mix of primary energy resources by renewable energy and fossil fuel with CCS in view of security, stability and sustainability—a vision on hydrogen supply chain by organic chemical hydride method. Nakata et al. [76] described recent trials of energy models application related to waste-to-energy, clean coal, transportation and rural development.

7 Other research progresses

We can also find many other research progresses in the engineering thermophysics discipline in term of theory, experiments and application [78–98], which are of significant help for the utilization of renewable energy. For example, Guo et al. [78] put forward a concept of entransy, which can be the central physical quantity characterizing heat transfer processes not related to heat-to-work conversions, and there are many relative interesting works that have been done [79–81].

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