附件 2　　浙江水利水电学院“南浔青年学者”申请表

<table>
<tr><td>姓　　名</td><td>聂婧</td><td>出生年月年龄（年龄）</td><td>1996 年 6 月（28 岁）</td><td>参加工作时间</td><td>2023 年 12 月</td></tr>
<tr><td>现所在单位（部门）</td><td>机械工程学院</td><td>最高学历/学位</td><td>博士</td><td>专业技术职务</td><td>讲师</td></tr>
<tr><td>符合条款</td><td colspan="5">符合科研类，科研成果，3 类论文 3 篇，5 类论文 1 篇，A 类著作（国家标准）1 项-绩点 270。</td></tr>
<tr><td rowspan="8">所涉业绩</td><td rowspan="2">教学类
绩点：_____</td><td colspan="4"></td></tr>
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绩点：270</td><td colspan="4">科研-科研成果-3 类论文 3 篇，5 类论文 1 篇-170 点，A 类著作（国家标准）-100 点
（1）Nie J, Yu M, Zhu P, et al. Technical strategy for reapplying coatings on solar tower receiver tubes using concentrated flux. Applied Thermal Engineering, 2025, 258 (SCI top，3 类论文-50 点)
（2）Nie J, Zhu P, Chen W, et al. Aging characteristic of solar coating and their cost-effectiveness. Solar Energy, 2022, 248: 183-195 (SCI top，3 类论文-50 点)
（3）Xiao G, Nie J, Xu H, et al. Performance analysis of a solar power tower plant integrated with trough collectors. Applied Thermal Engineering, 2022: 118853 (SCI top，博士期间导师一作，3 类论文-50 点)
（4）张春琳,周志伟,陈昕,祝培旺,肖刚，聂婧（通讯作者）.(2022).塔槽耦合光热系统镜场效率研究.热力发电(05),41-47.doi:10.19666/j.rlfd.202110190. (国内一级期刊浙大标准，5 类论文-20 点)
（5）国家标准 主要起草人 GB/T 41307-2022 塔式太阳能热发电站吸热器检测方法 （正式发布的推荐性国家标准-100 点）</td></tr>
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<tr><td>总绩点</td><td colspan="4">270</td></tr>
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标题: Technical strategy for reapplying coatings on solar tower receiver tubes using concentrated flux

作者: Nie, J(Nie, Jing);Yu, M(Yu, Miao);Zhu, PW(Zhu, Peiwang);Xiao, G(Xiao, Gang);

来源出版物:APPLIED THERMAL ENGINEERING **卷:**258 **文献号:**124680

DOI:10.1016/j.applthermaleng.2024.124680 **出版年:**JAN 1 2025

入藏号:WOS:001344301200001

文献类型: Article

地址:

[Nie, Jing] Zhejiang Univ Water Resources & Elect Power, Sch Mech & Automot Engn, Hangzhou 310018, Peoples R China.

[Zhu, Peiwang; Xiao, Gang] Zhejiang Univ, State Key Lab Clean Energy Utilizat, 38 Zheda Rd, Hangzhou 310027, Peoples R China.

[Yu, Miao] Xizi Clean Energy Equipment Mfg Co Ltd, Hangzhou 310027, Peoples R China.

通讯作者地址:

Xiao, G (corresponding author), Zhejiang Univ, State Key Lab Clean Energy Utilizat, 38 Zheda Rd, Hangzhou 310027, Peoples R China.

电子邮件地址:xiaogangtianmen@zju.edu.cn

IDS 号:K5M0U

ISSN:1359-4311

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标题: Performance analysis of a solar power tower plant integrated with trough collectors
作者: Xiao, G(Xiao, Gang);Nie, J(Nie, Jing);Xu, HR(Xu, Haoran);Zhang, CL(Zhang, Chunlin);Zhu, PW(Zhu, Peiwang);
来源出版物:APPLIED THERMAL ENGINEERING **卷:**214 **文献号:**118853
DOI:10.1016/j.applthermaleng.2022.118853 **出版年:**SEP 2022
入藏号:WOS:000823303000007
文献类型: Article
地址:
[Xiao, Gang; Nie, Jing; Xu, Haoran; Zhu, Peiwang] Zhejiang Univ, State Key Lab Clean Energy Utilizat, 38 Zheda Rd, Hangzhou 310027, Peoples R China.
[Zhang, Chunlin] Cent Southern China Elect Power Design Inst Co LTD, China Power Engn Consulting Grp, Wuhan 430071, Peoples R China.
通讯作者地址:
Zhu, PW (corresponding author), Zhejiang Univ, State Key Lab Clean Energy Utilizat, 38 Zheda Rd, Hangzhou 310027, Peoples R China.
电子邮件地址:zhupw@zju.edu.cn
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eISSN:1873-5606

第 2 条，共 2 条
标题: Aging characteristic of solar coating and their cost-effectiveness
作者: Nie, J(Nie, Jing);Zhu, PW(Zhu, Peiwang);Chen, W(Chen, Wei);Xu, HR(Xu, Haoran);Xiao, G(Xiao, Gang);
来源出版物:SOLAR ENERGY **卷:**248 **页:**183-195 **DOI:**10.1016/j.solener.2022.11.015 **出版年:**DEC 2022
入藏号:WOS:000950303000001
文献类型: Article
地址:
[Nie, Jing; Zhu, Peiwang; Xu, Haoran; Xiao, Gang] Zhejiang Univ, State Key Lab Clean Energy Utilizat, 38 Zheda Rd, Hangzhou 310027, Peoples R China.
[Nie, Jing; Zhu, Peiwang; Xu, Haoran; Xiao, Gang] Zhejiang Univ, Key Lab Clean Energy & Carbon Neutral Zhejiang, Jiaxing Inst, 966 Xiuyuan Rd, Jiaxing 314031, Peoples R China.
[Chen, Wei] Xizi Clean Energy Equipment Mfg Co Ltd, Hangzhou 310027, Peoples R China.
通讯作者地址:
Xiao, G (corresponding author), Zhejiang Univ, State Key Lab Clean Energy Utilizat, 38 Zheda Rd, Hangzhou 310027, Peoples R China.
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塔槽耦合光热系统镜场效率研究

张春琳[1] 周志伟[2] 陈昕[1] 祝培旺[1] 肖刚[2] 聂婧[2]

1.中国电力工程顾问集团中南电力设计院有限公司 2.浙江大学能源清洁利用国家重点实验室

摘要： 太阳能光热发电技术能量输出稳定，可用于电网调峰，是太阳能高效利用的重要方式。其中，塔式光热发电技术的集热储热温度高，系统发电效率高，具有很大的发展潜力。但由于余弦效率的影响，当塔式镜场容量超过一定限值时，镜场效率会随着镜场容量增大而降低，而槽式光热发电技术不受余弦效率影响且几乎与容量无关。因此，提出塔槽耦合的集热方案，并利用MATLAB软件对100 MW塔槽耦合光热发电系统进行光学效率仿真研究。结果表明：在总集热量不变的情况下，塔槽耦合光热系统年均光学效率达到50.65%，比单纯塔式镜场提高3.04百分点；当塔高为260 m时镜场效率比180 m时提高2.52百分点，同时塔与槽的镜场面积比从2.35降低至2.22；针对不同纬度和容量的塔槽耦合系统，提出了塔槽耦合镜场的适用范围，以期为新型太阳能光热发电系统的设计提供参考。

关键词： 塔槽耦合；光热发电系统；镜场；塔式；槽式；MATLAB软件；光学效率；

基金资助： 浙江杰出青年基金(LR20E060001)~~；

DOI： 10.19666/j.rlfd.202110190

专辑： 工程科技Ⅱ辑

专题： 电力工业

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APPLIED THERMAL ENGINEERING

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浙江大学能源工程学院

2023年11月8日

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2022-03-09 发布 2022-10-01 实施

国家市场监督管理总局
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本文件由全国太阳能光热发电标准化技术委员会(SAC/TC 565)归口。

本文件起草单位：中国能源建设集团有限公司、浙江大学、杭州锅炉集团股份有限公司、机械工业北京电工技术经济研究所、中国能源建设集团华东电力试验研究院有限公司、中关村新源太阳能热利用技术服务中心。

本文件主要起草人：许继刚、肖刚、许志贵、徐志强、许粲羚、王波、果岩、倪东、史跃岗、李鸿飞、聂婧、高嵩、杜凤丽、侯垚、罗飞、王慧军。

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塔槽耦合光热系统镜场效率研究

张春琳[1] 周志伟[2] 陈昕[1] 祝培旺[1] 肖刚[2] 聂婧[2]

1.中国电力工程顾问集团中南电力设计院有限公司 2.浙江大学能源清洁利用国家重点实验室

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基金资助： 浙江杰出青年基金(LR20E060001)~~；

DOI： 10.19666/j.rlfd.202110190

专辑： 工程科技Ⅱ辑

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分类号： TM615

Applied Thermal Engineering 258 (2025) 124680

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Research Paper

Technical strategy for reapplying coatings on solar tower receiver tubes using concentrated flux

Jing Nie [a], Miao Yu [c], Peiwang Zhu [b], Gang Xiao [b,*]

[a] School of Mechanical and Automotive Engineering, Zhejiang University of Water Resources and Electric Power, Hangzhou 310018, China
[b] State Key Laboratory of Clean Energy Utilization, Zhejiang University, 38 Zheda Road, Hangzhou 310027, China
[c] Xizi Clean Energy Equipment Manufacturing Co., Ltd., Hangzhou 310027, China

ARTICLE INFO

Keywords:
SPT plant
Recoating
Aimpoint strategy
Characteristic
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ABSTRACT

Reapplying the coating is crucial to restore optimal receiver performance. However, the heat treatment must be conducted onsite since the receiver cannot be removed from the tower. This study explored effective strategies for maximizing the coating's performance after reapplication. The impact of different aimpoint strategies on the receiver's surface temperature was analyzed using the heliostat field and the three-dimensional receiver model. Experimental tests were conducted using a solar lamp to study temperature variation curves of coatings on different tube panels under various aiming strategies, and absorptance was then measured. The optimal recoating strategy was determined through a comprehensive analysis of the system's power generation and its Levelized Cost of Energy across its entire lifecycle. The "image size priority" strategy led to significant temperature variations among tube panels and within each panel. In contrast, the "segmented target flux" strategy effectively minimizes temperature differences, ensuring that over 91.25 % of the receiver tube panel reached temperatures above 550 °C. Comparatively, under the "image size priority" and "segmented target flux" strategies, the coating's absorptance at the molten salt inlet panel is lower by 1.84 % and 0.10 %, respectively, compared to the standard sample. The effectiveness of the "segmented target flux" strategy becomes more pronounced with shorter recoating intervals. The research contributes to enhancing the maintenance performance of the coating and the operational efficiency of the receiver.

1. Introduction

Solar receivers, integral to solar power tower (SPT) plants, are responsible for capturing solar energy reflected by heliostats [1]. The efficacy of receiver surface coatings directly impacts energy absorption and radiation losses, thus crucially influencing thermal efficiency. Over time, the operation of receivers leads to a gradual decline in the optical performance of the coatings. The absorptance of the coating decreases sharply to 92 % after approximately 600 days and further declines to 90.74 % by the third year [2]. This reduction in absorptance results in a 6.3 % decrease in system efficiency by the third year. Consequently, the reapplication of solar coatings becomes essential to maintain the efficiency and durability of solar receiver materials.

Wen et al. [3] investigated the impact of the concentration ratio on coating absorptance, recommending high-absorptance coatings for tower receivers with concentration ratios between 500 and 1000. Lopez-Herraiz et al. [4] simulated the effects of various coatings on receiver thermal performance, revealing that receivers employing non-selective absorptive coatings achieve superior thermal efficiency. However, selective absorptive coatings with low emissivity are essential for enhancing the performance of cavity receivers. Black spinel oxides, such as Cr-Mn spinel, exhibit high absorptivity and are extensively used as coatings for tower solar receivers [5]. Tulchinsky et al. [6] synthesized a novel coating material, $Cu_{0.44}Ti_{0.44}Mn_{0.84}Fe_{0.28}O_3$, for solar thermal applications through a thermal reaction involving sol–gel titanium dioxide precursors and copper-manganese spinel. Wang et al. [7] proposed a method to locally integrate spectrally selective coatings in the Negative Thermal-Flux Regions (NTRs) of tower receivers. The results demonstrate that spectrally selective coatings locally integrated with NTRs effectively adjust the radiation characteristics of NTRs, thereby reducing radiative heat losses.

Pyromark is an organosilicon coating widely used as a commercial coating on the surface of tower receivers. Ambrosini et al. [8] investigated the influence of the application process on the performance of Pyromark coatings after aging. They found that coating thickness,

* Corresponding author.
E-mail address: xiaogangtianmen@zju.edu.cn (G. Xiao).

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Available online 19 October 2024

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Aging characteristic of solar coating and their cost-effectiveness

Jing Nie [a,b], Peiwang Zhu [a,b], Wei Chen [c], Haoran Xu [a,b], Gang Xiao [a,b,*]

[a] State Key Laboratory of Clean Energy Utilization, Zhejiang University, 38 Zheda Road, Hangzhou 310027, China
[b] Key Laboratory of Clean Energy and Carbon Neutrality of Zhejiang, Jiaxing Institute of Zhejiang University, 966 Xiuyuan Road, Jiaxing 314031, China
[c] Xizi Clean Energy Equipment Manufacturing Co., Ltd., Hangzhou 310027, China

ARTICLE INFO

Keywords:
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ABSTRACT

Pyromark 2500 high-temperature coatings are widely used on the surface of solar power tower (SPT) receivers. However, the optical properties of these coatings decrease with increasing working time. Experimental conditions for aging tests, such as aging temperature and temperature change, were obtained using a three-dimensional model. The isothermal temperature was 630 °C for constant high-temperature aging test. The temperature variation rate was 20 °C/min and 330 °C/min for slow- and extreme-temperature-variation aging tests, respectively. The absorptance of the coating on Inconel 625 decreased by 0.18 %, 1.49 %, and 1.09 % after 2800 h at constant-high-temperature, after 2000 cycles under slow-temperature-variation, and after 100 cycles under extreme-temperature-variation, respectively. Moreover, the aged coating was characterized via scanning electron microscopy and energy dispersive spectroscopy. An innovative on-site test method for determining the absorptivity by mining operational data is proposed in this study. The absorptivity is 92.44 % and 90.74 % after 580 days and 1117 days of operation, respectively, obtained from the test data and the simulation results of the Solar Two receiver. The electricity loss due to coating absorptivity attenuation was 24447.6 MWh over three years without reapplication. Furthermore, the optimal reapplication interval ranged from 2 to 3 years, which is determined by the levelized cost of energy (LCOE).

1. Introduction

Concentrating solar power (CSP) technology can achieve continuous and stable power output by coupling with a cost-effective heat storage system (Conroy et al., 2020). The solar receiver is the key solar thermal conversion device of the CSP plants to receive the concentrated solar flux reflected from the mirrors (Wang et al., 2021). The high-temperature coating on the collector surface is the key technology that determines the efficiency of the receiver. Black spinels such as Cr-Mn-spinel have a high absorptance and are widely used in coatings for SPT receivers (Meißner et al., 2019). Pyromark is a silicone-based coating widely used for solar absorber coatings. Martinez et al. (2020) studied the Pyromark treatment process and found the durability of the coating could be improved by controlling the curing and vitrification process of the coating. The best treatment was curing at 125 °C for 2 h, followed by vitrification at 250 °C for 1 h. Coventry et al. (2017) applied Pyromark 2500 coatings of different thicknesses to substrates and found thinner coatings to be as good as or better than thicker ones.

However, the performance of high-temperature coatings is prone to optical performance degradation, cracking, and peeling with increasing time. Experiments at high temperature showed that higher aging temperature leads to worse coating performance. Ambrosini et al. (2016) aged Pyromark 2500 at 600 °C, 700 °C and 800 °C for 480 h and found the absorptance of the coating was nearly constant at 600 °C, slightly decreased at 700 °C and decreased the most at 800 °C. X-ray diffraction (XRD) testing of the coatings at the three test temperatures showed the pattern at 600 °C was similar to the initial Pyromark coating even after 480 h, and secondary phases appeared at 700 °C and 800 °C. Hosseini et al. (2022) found that the optical properties of Pyromark coatings were stable after aging at 800 °C for 3000 h and continued to decrease at 900 °C. Rubin et al. (2019) sprayed Pyromark 2500 on Haynes 230 and annealed it at 800 °C. The XRD analysis and scanning electron microscopy (SEM) showed that the lack of significant particle growth was possibly due to the Jahn-Teller distortion of copper (II) ceramics, lowering the energy of the nanoparticle at elevated temperatures. Noč et al. (2019) analyzed the coatings after a long-term exposure under limited isothermal conditions and found that the forming of a protective layer on the substrate surface was the main degradation factor.

Some researchers have also studied the coating aging characterization under different energy flux and thermal cycling rates. Boubault et al. (2012) developed solar accelerated aging facilities (SAAF) and

* Corresponding author at: State Key Laboratory of Clean Energy Utilization, Zhejiang University, 38 Zheda Road, Hangzhou 310027, China.
E-mail address: xiaogangtianmen@zju.edu.cn (G. Xiao).

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Research Paper

Performance analysis of a solar power tower plant integrated with trough collectors

Gang Xiao [a], Jing Nie [a], Haoran Xu [a], Chunlin Zhang [b], Peiwang Zhu [a,*]

[a] State Key Laboratory of Clean Energy Utilization, Zhejiang University, 38 Zheda Road, Hangzhou 310027, China
[b] Central Southern China Electric Power Design Institute Co., LTD of China Power Engineering Consulting Group, Wuhan 430071, China

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ABSTRACT

The heliostat field efficiency is essential for solar power tower (SPT) plants. However, the heliostat field efficiency decreases rapidly with increasing capacity of the SPT plants, limiting the development of large-scale SPT plants. This study developed a system that couples trough collectors with an individual SPT plant, including a mid-temperature tank and solar-aided feedwater heating system. The suggested concentrating area ratio of heliostats to parabolic-trough mirrors ranges from 2.1 to 2.4. Both the area ratio and mid-temperature tank capacity were optimized by considering the levelized cost of electricity (LCOE). The optical efficiency and electricity generation values of the 100-MW integrated system were higher than those of an individual SPT plant (3.19% and 5.92%, respectively). Electricity generation increased significantly with decreasing latitude, and the LCOE decreased slowly with the increasing capacity. This study contributes to the large-scale use of SPT plants.

1. Introduction

Developing solar power technologies is a key solution to eliminating the global economy's dependence on fossil fuels [1]. CSP technologies can couple with a large-scale and low-cost heat storage system to achieve continuous and stable power output [2]. CSP is predicted to contribute approximately 11%–12% to global electricity production by 2050 [3]. CSP plants include solar parabolic dishes (SPD), parabolic-trough collectors (PTC), solar power towers (SPT), and linear Fresnel reflectors (LFR) based on the concentrating modes [4]. M.H. Ahmadi et al. [5] compared various solar thermal power plants and discovered that PTC is more efficient than LFR. P. Iodice et al. [6] discovered the optimal vaporization temperatures of a direct steam PTC system based on the increase in two screw expanders from around 186 °C to 245 °C with increasing solar radiation. Further, P. Iodice et al. [7] discovered that Scheffler solar receivers can perform better than PTC. SPT plants can attain a concentration ratio of 200–1000, resulting in a higher operating temperature and efficiency [8]. D.S. Reddy et al. [9] presented a review of stationary point focus solar concentrators and discovered that SPT is more preferred than SPD. O. Achkari et al. [10] reported that large-scale SPT plants with thermal energy storage (TES) systems are more cost-effective than PTC plants due to the significant reduction in the levelized cost of electricity (LCOE).

The CSP can also couple with other systems in addition to stand-alone applications. E.M.A. Mokheimer et al. [11] developed an integrated solar-tower gas-turbine-cogeneration power plant. This plant reduced the levelized electricity cost by 50%–60% compared with the stand-alone SPT plant. L. Elmorsy et al. [12] developed a novel natural gas-fired integrated solar combined-cycle power plant that uses direct steam LFR, and the system's exergetic efficiency reached up to 59.8%. A. E. Elmohlawy et al. [13] developed a system that uses a PTC solar field to generate part of the high-pressure steam in tandem with the evaporator. The results showed that the net solar-to-electricity efficiency ranged annually from 44.74% to 48.24%. G. Franchini et al. [14] discovered that the integrated solar combined cycles (ISCC) coupled with a solar tower achieve the highest annual solar-to-electric efficiency of 21.8%, which was higher than that of PTCs. H. Liu et al. [15] compared the performance of ISCCs using different solar concentration technologies such as PTC, LFR, and SPT. They discovered that the parabolic trough and tower coal-fired generation (PTCG) performed best. The PTCG's off design performance was investigated, and the maximum solar energy was increased by 28.5%, 20.0%, and 14.3% under three different loads of 100%, 75%, and 50% [16]. Y. Li et al. [17] proposed a new ISCC, in which PTCs with DSG technology and nonconcentrating solar collectors are simultaneously integrated into the combined system. Moreover, this new system's LCOE was predicted to be 20% lower than that of an ISCC-DSG system. S. Peng et al. [18] studied a solar-hybrid coal-fired power

* Corresponding author.
E-mail address: zhupw@zju.edu.cn (P. Zhu).

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塔槽耦合光热系统镜场效率研究

张春琳[1]，周志伟[2]，陈 昕[1]，祝培旺[1]，肖 刚[2]，聂 婧[2]
（1.中国电力工程顾问集团中南电力设计院有限公司，湖北 武汉 430071；
2.浙江大学能源清洁利用国家重点实验室，浙江 杭州 310027）

［摘 要］太阳能光热发电技术能量输出稳定，可用于电网调峰，是太阳能高效利用的重要方式。其中，塔式光热发电技术的集热储热温度高，系统发电效率高，具有很大的发展潜力。但由于余弦效率的影响，当塔式镜场容量超过一定限值时，镜场效率会随着镜场容量增大而降低，而槽式光热发电技术不受余弦效率影响且几乎与容量无关。因此，提出塔槽耦合的集热方案，并利用 MATLAB 软件对 100 MW 塔槽耦合光热发电系统进行光学效率仿真研究。结果表明：在总集热量不变的情况下，塔槽耦合光热系统年均光学效率达到 50.65%，比单纯塔式镜场提高 3.04 百分点；当塔高为 260 m 时镜场效率比 180 m 时提高 2.52 百分点，同时塔与槽的镜场面积比从 2.35 降低至 2.22；针对不同纬度和容量的塔槽耦合系统，提出了塔槽耦合镜场的适用范围，以期为新型太阳能光热发电系统的设计提供参考。

［关 键 词］塔槽耦合；光热发电系统；镜场；塔式；槽式；MATLAB 软件；光学效率
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Study on optical efficiency of tower slot coupling solar thermal power generation system

ZHANG Chunlin[1], ZHOU Zhiwei[2], CHEN Xin[1], ZHU Peiwang[1], XIAO Gang[2], NIE Jing[2]
(1. Central Southern China Electric Power Design Institute, Wuhan 430071, China;
2. State-level Key Laboratory of Clean Energy Utilization, Zhejiang University, Hangzhou 310027, China)

Abstract: Solar thermal power generation technology is an important way of efficient utilization of solar energy due to its stable energy output and can be used for peak regulation of power grid. Solar tower power generation with high collection and storage temperature has high power generation efficiency and great development potential. However, due to the influence of cosine efficiency, the optical efficiency of the heliostat field will decrease when the capacity exceeds a certain limit. On the contrary, the field efficiency of the trough collector is not affected by cosine efficiency and is independent of capacity. Therefore, a method of coupling tower and trough collector is proposed to improve the efficiency. MATLAB software is used to simulate and study the optical efficiency of the 100 MW tower slot coupling solar thermal power generation system. The results show that, the average annual optical efficiency of the coupling system can reach 50.65% under the condition of constant total heat collection, which is 3.04 percentage points higher than that of single tower system. When the tower height is 260 m, the optical efficiency of the coupling system is 2.52 percentage points higher than that of 180 m, and the ratio of heliostat field area to parabolic trough collector area decreases from 2.35 to 2.22. According to the tower slot coupling system with different latitudes and capacities, the variation regulation of the optical efficiency of the heliostat field is analyzed, and the application range of the tower slot coupling system is proposed, which is expected to provide reference for the design of new solar thermal power generation system.

Key words: tower slot coupling; solar thermal power generation system; heliostat field; tower; trough; MATLAB software; optical efficiency