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不同指标轻小型喷灌机组配置优化

Optimization of small-scale sprinkler irrigation systems for different indicators

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中文摘要:

为探究配置方式对喷灌机组整体性能的影响，明晰不同配置方式的特点，在前期调研的基础上，以轻小型灌溉机组4.4CP-45为例，分别以单位面积上资源消耗，如机耗、年费用及使用年限内总费用等为评价指标，结合实际使用配置方式，采用遗传算法，讨论平坡条件下配置不同喷头10PXH、15PY、20PY及40PY时的喷头数及管径等优组合方式，并对每种配置方式的适用范围进行分析。研究结果表明，通过3个优化目标下机组最优配置方式的对比，较好地反映出每种配置方式的优劣，与实际使用吻合较好。配置40PY喷头时，机组单位能耗高，但年费用很低，适于抗旱或大田作物的灌溉；配置15PY喷头时，优化配置下的机组能耗比初始配置时降低7.3%，比配置Y降低8.3%，同时各项费用都比较低，灌溉均匀性高，但移动时劳动强度较大，适于经济作物或植物幼苗的灌溉；配置20PY喷头时，机组总费用最低，为6284.8元/hm2，初始配置降低15.4%。所有配置方式下能耗费、运行费分别占据机组年费用及总费用的主要部分，有必要通过配置优化或采用中低压喷头、改善管理以降低系统能耗。研究可以为机组的合理设计、喷头选择及应用推广提供参考。

英文摘要:

Abstract: The optimal design of a sprinkler irrigation system belongs to a class of large combinational optimization problems. It involves choosing the proper type and number sprinklers and pipe diameters, and operating them at rational pressure heads according to the characteristics of pump and motor equipment. Theoretically, the optimization has rar been addressed on the small-scale sprinkler irrigation systems compared to applications of the systems. Based on a survey done in cooperation with the factory, a small-scale spri machine type 4.4CP-45 that can be equipped with fluidic sprinklers 10PXH, impact sprinklers 15PY, 20PY or 40PY, was taken as an example to investigate the impact of designs on performances of system laid on a flat ground so that the characteristics of different designs involved can be summarized. The optimization models were built with three objective functions considering the resource consumptions per unit area irrigated, specific energy consumption, annual cost and total cost in a life cycle of the system separately subject to constraints considering the pump-pipeline working conditions. The specific energy consumption here refers to the energy consumption per unit area with unit depth of water appl and a static depreciation method was applied in the annual cost, while a dynamic method in the total cost. In the hydraulic calculation a back step method was introduced, and the optimization models were solved with genetic algorithms. Results show that: comparison of optimal designs under three objective functions will reflect the advantages and disadvantages of every scheme involved, which is in accordance with field practices and applications. When the irrigation system is equipped with one sprinkler typed 40PY, the specific energy consumption is high, and annual cost very low, so it's suitable for the irrigation of lands in serious drought or for the field crops. When equipped with 15 sprinkler typed 15PY, the specific energy consumption of the system under optimal design is 7.3% lower than that before optimization, 8.3% lower than that of the system equipped with sprinklers typed 20PY. All the indicators of the system are low, and it will show a high irrigation uniformity, but it is labor intensive in moving, thus it's applicable for profit crops o young plants. When 7 sprinklers typed 20PY are used, the total cost of the system is at its lowest, 6 284.8 Yuan/hm2, 15.4% lower than that of the initial design, and it is practical f many occasions. In the economical analyses of the system, the energy consumption fee or operation fee in any scheme constitutes a major part of the annual cost or the total cost respectively. Therefore, to reduce the energy consumption of irrigation systems through optimization or introduction of low pressure sprinklers is now an important task.

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