Intelligent Energy Saving Control of UV lamp in water filter

Trupti N. Bhoskar, Prof. V. R. Ingle

Abstract — Interest in using ultraviolet (UV) light to disinfect drinking water is growing among public water systems due to its ability to inactivate pathogenic microorganisms without forming regulated disinfection byproducts. Ultraviolet water purification is a unique and rapid method of water disinfection without the use of heat or chemicals. Through the years ultraviolet technology has become well established as a method of choice for effective and economical water disinfection. In order to disinfect properly, conventional UV water-treatment systems keep their light intensity at maximum level regardless of the operating condition; this will result in unnecessary energy waste along with lamp-life-span reduction. In this paper, a UV water treatment system is proposed with intelligent energy saving control of UV lamp For the purposes of energy saving, fuzzy rule based control system is proposed to dim the luminance of the UV lamp according to the measured water flow rate, temperature and amount of impurity.

Index Terms- Intelligent, Energy saving, ultraviolet (UV) disinfection, water-treatment, UV lamp, fuzzy logic controller, UV light.

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1. INTRODUCTION

Over the past few decades, ultraviolet (UV) water treatment has become widely recognized and accepted by regulatory agencies as a proven disinfection process. With the increased awareness of health concerns and water quality, UV disinfection is quickly gaining popularity in the consumer market as a safe, effective, and economical approach to disinfection. UV radiation is generated by a special lamp. It effectively destroys bacteria, viruses, and cysts by penetrating cell walls and rendering the organisms unable to reproduce. Ultraviolet light disinfection is effective on bacteria, protozoan parasites(e.g. *Giardia, Cryptosporidium*), and can also be effective for most viruses, providing sufficiently high UV dosage rates are used.UV disinfection is suitable for a number of residential and commercial uses of water such as: Agriculture: Livestock, Irrigation, Dairy, etc., Domestic drinking water, residential use, Domestic drinking water, municipal use, Food and Beverage Industry, Breweries, Wineries, Secondary treatment of municipal wastewater.

UV light assemblies are self-contained—water flows around the UV lights, which are housed in protective sleeves. Effectiveness is influenced by light intensity and contact time. UV water-treatment systems vary in water-tank size and UV lamps used. It is important that the UV system should provide a sufficient amount of applied UV energy in order to disinfect properly. The term used to measure this amount of UV energy is called dosage. UV dosage is a product of the UV intensity with the unit (in microwatts per square centimeter) and the exposure time (in seconds).Factors Effecting UV Dose are given as follows:1) Flow Rate 2) Ultraviolet Transmittance 3)Water Quality(Hardness/Iron)/Turbidity.

UV water-treatment systems vary in water-tank size and UV Lamps used. In most designs, the UV-light dosage (dosage is Defined as UV intensity multiplied by time) is kept at maximum level in order to maintain the bacteria-killing capability. In addition, the UV lamps usually have life-span limitation and require periodical replacement. With the aging of the UV lamps, the output power of the UV lamps decreases and, hence, the disinfection effect also declines. In order to deal with this problem, many UV equipment are designed to provide more UV-light intensity at the beginning phase of usage. However, this is not necessarily the right solution in terms of cost and energy consumption. A better approach is to use an intelligent UV-light control technology, which can only be found on enterprise-level water-treatment systems. In these systems, water temperature, water-flow-rate sensor, or extra UV lamps will be used to control the UV-light intensity and energy consumption. Therefore, these systems are complex and bulky and are not suitable for residential point-of-entry (POE) users.

In this paper, a UV water treatment system is proposed with intelligent energy saving control of UV lamp For the purposes of energy saving, fuzzy rule based control system is proposed to dim the luminance of the UV lamp according to the measured water flow rate, temperature and amount of impurity**.** A multiple input to the given system is water flow rate, temperature and impurity. And output is required UV intensity.
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2. LITERATURE ANALYSIS

[1] In this paper, In this paper, a new design of high power-factor low-cost electronic ballast with intelligent control for UV water-treatment system is proposed.. For the purposes of energy saving, intelligent-control algorithm is proposed to dim the luminance of the UV lamp according to the measured water flow rate and UV light intensity. The proposed UV ballast system can be divided into four major parts: μ-controller-based intelligent controller, UV lamp, power-factor-correction (PFC) stage, and output-power stage. The proposed system uses MSP430F149 μ controller to implement the intelligent controller and provide the gating signals. The gating signals are delivered to the PFC and the power stage. Asymmetrical half-bridge inverter is used in this paper to achieve the goals of zero-voltage switching. In order to demonstrate the energy-saving capability of the proposed controller, the measured monthly energy consumption of the water-treatment system, with or without the proposed controller, is provided. Experimental results for two drinking-water-usage scenarios (the monthly drinking water consumption Vhome is 300 L/mo for scenario one and 450 L/mo for scenario two) are provided. According to the recorded data, the energy consumption for scenario one, with/without the proposed

controller, is 14.04 kWh/28.08 kWh; the energy consumption for scenario two, with/without the proposed controller, is 14.041 kWh/28.08 kWh. The FLC implemented in this paper is a two-input–single output controller. The inputs are the water flow rate wflow and the measured UV intensity Pouv. The output of the FLC is the required UV intensity Pduv. According to the experimental results, the energy-saving capability of the proposed system is better than 50%, and the measured microorganism reduction rate is better than 99.9%.The measured power factor is 0.975. [2] In this paper, a new design of high power factor low cost electronic ballast with intelligent energy saving control for water-treatment system ultraviolet lamps (UVL) drive is described. In order to design high performance ballast for UVL drive, a full-automatic general circuit components design platform and post verification system are implemented. Cooperating with the developed graphic user interface (GUI), the design performance and effectiveness can be predicted in this integrated GUI environment through the computer simulation and data computation. Here for the purposes of energy-saving, bacteria killing factors, and light lifespan extension, an intelligent green mode control is presented to dim the luminance of the UVL according to the sensed flow and illumination signals. In order to meet the minimum bacteria killing function, the ultraviolet light power is 32.6W~19.5W which is 83.6%~50% of the rating power. With light sensor and intelligent control used in this paper which can automatically dim the UVL luminance to meet the minimum bacteria killing function and minimum power consumption. In experimental result, it is found that The PFC improves the power factor and the power loss has been very effective. While, the harmonic is greatly improved as the electronic ballast has been installed PFC. The total harmonic distortion (THD) is 55% and 15% for uninstalled and installed PFC respectively. On the other hand energy consumption per month for traditional water treatment system and the proposed case is 28kWH and 14kWH, respectively. Energy saving capability is better than 50%. [3] The paper analyses the possibility to implement this new technique in daylighting control and presents the structure of a fuzzy controller. The day lighting control is based on continuous dimming techniques that allow users to adjust lighting levels over a wide range of lighting output and offer far more flexibility than step-dimming controls. As continuous dimming follows the daylight pattern very closely, it is often more acceptable to occupants, and can produce higher energy savings, particularly in areas with highly variable cloud cover. Continuous dimming also responds to changes in light output due to dirt depreciation on fixtures and lamps, and lamp lumen depreciation due to lamp aging. Continuous dimming is achievable using either analog or digital ballasts. The day lighting fuzzy control uses a fuzzy controller as the logic circuit of the lighting control and continuously electronic dimming ballasts controlled by low-voltage analog signals as power controllers. The ballast receives a signal from the control device and subsequently changes the current flowing through the lamp, thereby achieving a gradual controlled reduction in lamp output. The characteristics of the control signal affect the duration and extent of the change in current and subsequent lamp output. The proposed day lighting fuzzy control uses four sensing devices (an occupancy/motion sensor and three photo sensors), continuously electronic dimming ballasts for every luminaries aiming the control of the electric lighting output, and a fuzzy controller. Data obtained by simulation proved the correctness of the proposed solution.[4] This paper presents the analysis and design of a series-resonant parallel-loaded inverter applied to electronic dimming ballasts with bifrequency and fuzzy logic control. The power levels in between are controlled by varying the ratio between two time intervals for which the two frequencies last, respectively. This mechanism is achieved by using a fuzzy logic controller (FLC).A ballast prototype with the FLC which is implemented on an 8-bit microprocessor with a reduced instruction set computer architecture has been built. Experimental measurements have shown the feasibility of the ballast with the proposed control strategy. In this paper, a fuzzy logic controller (FLC) is applied to the lighting systems, in which the lamp parameters, the component values, and input voltage might vary over a wide range, and an accurate dynamic model for ballast, associated with fluorescent lamps is hard to obtain. With this technique, high-performance electronic dimming ballast can be readily designed and developed. In the proposed ballast, a low-cost 8-bit microcontroller using reduced instruction set computer (RISC) architecture is employed to serve as the FLC. Due to the very limited internal memory space and low clock rate, it is difficult to control the luminous output of the lamp by continuously varying the switching frequency of ballast. To keep a low cost while still sustaining high performance, a bifrequency control (BFC) scheme, which arithmetically averages the output power over the time durations of the two frequencies, in conjunction with the fuzzy logic control is adopted to control a dimming system. That is, during dimming operation, the ballast is operated only at two distinct frequencies alternately, and each of which stays for a certain time interval; thus, the output power can be controlled by adjusting the ratio of the two time intervals. Here author concluded that a bifrequency control algorithm realized with an FLC has been successfully applied to an electronic dimming ballast system. The two frequencies are corresponding to the maximum and the minimum lamp currents. The currents in between are obtained by adjusting the duration of each frequency, thus achieving a dimming feature. The interpolation method is introduced in the realization of the FLC, which reduces the required memory space dramatically and, in turn, reduces the system cost.[5]] Disinfection of waste and drinking water using ultraviolet (UV) light has become a recognized method of protecting public health as part of a multiple barrier approach. UV provides an ideal method to inactivate harmful pathogens that are resistant to treatment by chlorine, allowing the use of less chlorine so that less chlorinated carcinogenic byproducts are present in drinking water. The most widely accepted UV light sources for disinfection are low and medium pressure mercury arc lamps. The advantages and disadvantages of both light sources for disinfection are highlighte.Ultraviolet light in the UV-C (200-280 nm) and UV-B(280-315 nm) bands [1] show germicidal action, where the~230-300 nm wavelength region is considered the most effective for disinfection [2]. UV light is absorbed by the nucleic acids of pathogens, causing chemical reactions which prevent the pathogen from reproducing. Inactivation of pathogens increases with the UV influence (also called UVdose), light influence rate multiplied by the exposure time, so UV light sources with sufficient influence rate in the 230-300 nm wavelength range are highly desirable for disinfection. The most widely accepted UV light sources are low-pressure mercury arc lamps that emit light at 254 nm, or medium pressure lamps that emit light at many wavelengths over the UV and visible regions of the spectrum. Both low and medium pressure mercury lamps are practical light sources for providing the germicidal irradiance needed for UV disinfection. Low-pressure lamps offer higher conversion efficiency of electrical power, with monochromatic light output that can be adjusted in a feedback control system with any solar-blind photodiode. Medium pressure lamps offer much higher irradiance per unit length of arc, and function well using photodiodes with germicidal wavelength response to avoid errors in maintaining germicidal irradiance, since the output of these lamps is polychromatic. The ideal light source would have high irradiance near the peak germicidal response of ~260 nm, and minimal output outside the germicidal wavelength range of ~230-300 nm.

[6] This paper presents a real world challenge of constructing an energy efficient portable ultra-violet-based water sterilizer. We discuss a novel approach where UV radiation has a dual use, (i) to detect microbial activity through bio fluorescence, and (ii) to sterilize the water. This dual use scenario enables us to propose a feedback control based operation scheme. We propose mathematical model for both the detection and sterilization process, based on experimental data. One of the main facts that we gather from the experimental data is that the optimal UV wavelength range for sterilization and detection are different. Sterilization is most effectively achieved at _265 nm wavelength, while detection is peaked at _340nm wavelength. Based on this observation, we propose the incorporation of both processes in its most basic form as follows.

1) A batch of drinking water is put into the system. The system begins the detection mode with 340 nm LEDs within the lamp pulsing at an optimized frequency.

2) Detectors sensitive to emission at 440 nm receive microorganism fluorescence only at the corresponding frequency.

3) A threshold, determined by the intensity of the fluorescence signal over noise from the system, initiates the switch to sterilization mode or idle mode for an allotted time.

4) If sterilization is required, the 265 nm LEDs within the lamp emit light with the radiation intensity and time of exposure varied by the outcome of the detection process.

5) System operation is completed when the microbial content in the water is driven below a predetermined threshold. One of the novel aspects in this project is the technology that will enable the use of UV both as detection and sterilization agent. To this end, they formulate a mathematical model for both the sterilization and the detection process and propose a basic operation scheme involving both of them. They identify several directions, in which future research will be conducted. First, to develop the missing mathematical model for the detection process, and solve the optimal detection problem as outlined in the previous section. Second, we so far assume that the model parameters (T, K,and ג) are known. In reality, they might not be known or only known up to a certain probabilistic distribution. [7 Here it is observed that applied filtration methods on ballast water treatment may have problems of low efficiency, low flow rate or short lifespan. So a novel micro-pore ceramic filter (MPCF) is used to combine with UV. To evaluate the performance of the new approach, alga removal percentages and oceanic bacteria inactivation rates were studied on simulated ballast water mixing with indicator algae. They were compared with single MPCF treatment and UV treatment at different flow rates and alga concentration**.** A self-designed MPCF&UV ballast water treatment system was set up in the lab. It mainly consist of storage banks, centrifugal pump, filter, UV lights. The cylinder filter is made in ceramic materials, with diameter of 19cm and volume of 6L. Three sampling taps are set before treatment, after filtration and after UV radiation. Since MPCF is obviously useless on bacteria inactivation and UV alone is low efficient on alga removal, MPCF&UV performance on simulated ballast water is compare with the two single methods on alga removal and bacteria inactivation separately.

A. Comparison on Alga Removal

B. Bacteria Inactivation Analysis

In conclusion, MPCF has higher removal percentage on alga than other applied filtration method since its special wall-flow structure. MPCF alone and UV alone cannot obtain high performance on phytoplankton or oceanic bacteria. When the two methods combined, MPCF as the primary treatment can remove large amounts of algae, so UV radiation ability is boosted with the increase of transparence rates.[8] This paper presents a comparative study on the performance characteristics between the variable switching frequency and variable dc link voltage control schemes for the dimming operation of electronic ballasts using a half-bridge series-resonant parallel-loaded inverter. Attributes under investigations include1) average input current of the inverter;
2) Dimming characteristics; 3) variations of the filament power and starting voltage throughout the dimming range;4) dead time boundaries for ensuring zero-voltage-switching in the inverter. **D**immable electronic ballasts for fluorescent lamps have been increasingly accepted in residential, commercial, and industrial lighting applications. Important factors in the design of electronic ballasts are high power factor, low total harmonic distortion, low electromagnetic interference (EMI), low lamp current crest factor, and low flickering. Dimming can be achieved by the following two possible methods

a) Constant DC Link Voltage with Variable Switching Frequency b) Variable DC Link Voltage with Constant Switching Frequency*:* In experimental verification two 36W electronic ballast prototypes, which are controlled by VFS and VVS, respectively, have been built and tested. So here conclude that a comparative study on the performance characteristics between the VFS and the VVS is presented. By using the fundamental-frequency model and the nonlinear lamp resistance characteristics, the steady state solution and starting voltage characteristics have been derived. It has been shown that the VVS has several operational advantages over the VF in dimming operation.[9] This paper presents the design of a resonant inverter that unifies the two basic functions of ballast: the generation of an initial over-voltage and the current control after the start-up. The chosen topology is a half bridge parallel resonant inverter (PRC); its behavior in the frequency domain is reviewed when driving a high pressure sodium (HPS) lamp. The dimming control is performed by shifting the snitching frequency of the resonant inverter within the range above resonance. The ignition of the lamp is divided into two periods: start-up time and warm-up time. A soft-start method minimizes the initial over-voltage applied to the lamp, and reduces the current stress on the circuit components. Experiments have been carried out on ballast driving an IIPS NAV701; Imp by OSRAM. The given nominal values ;re VI,,,,,=XOV,,, and I1,,,,,=O.87SAmW which results in a11 equivalent resistance Rlanlr=91&2W.w ith the available voltage source V,,,=300V and the natural frequency fixed either ;it ,fl=SOkIIz or f,=2SkHz, by using (4). The quality factor is Q,=0.5921. Qp, RI amp and determine 7,=157.6L2. From Z, the reactive components; re, lor ,J)=SO kIIz, b496pH and C=20.6nF.For the c;isc of the fluorescent kunp the design steps are similar but considering VI,,,,,=98V,,,, and a current of II,,,,,~=O.~~A,,I~, .So it is conclude that A half-bridge PR(' is a low cost circuit that achieves high efficiency to implement electronic ballast for 70 W HPS lamps and fluorescent tubes. Based on this topology, a dimming control and a soft start-up method have been carried out by varying the switching frequency in *suitable* way. The HPS lamp behaves as a constant resistance at high frequency, maintaining the value of its equivalent resistance constant when the dimming control is applied. The nominal switching frequency is fixed free of acoustic resonance.

The proposed soft-start method controls the increase of the current and voltage stress, achieving that the lamp start-up occurs without exceeding the ionizing conditions of the gas enclosed in the lamps.

3. FUZZY LOGIC CONTROLLER

Fuzzy Logic is a practical alternative for challenging control applications that provides a convenient method for constructing nonlinear controllers via the use of heuristic information from human designers. Such heuristic information is recorded in rules describing how to control the process. Fuzzy Logic emulates the human decision making process, and provides a user-friendly formalism for representing and implementing high-performance control at low cost. Until recently, Fuzzy Logic has been used primarily on large-scale computing systems, at least at the level of personal computers. Recent advances, however, make it realistic to implement Fuzzy Logic techniques on small systems based on microcontroller. Fuzzy Logic controller forms the base of the Fuzzy Control tem. It basically consists of the heuristics rules those define the parameters. It consists of:

- Data Base*:* It normalizes the input input crisp values and contains the fuzzy partitions of the input and output space.
- Fuzzy Rule Base*:* It contains the type of fuzzy rules and the source and derivation of the fuzzy control rules
- Fuzzy Inference Machine: The basic function is to compute the overall output of the control output variable based on the individual contribution of each rule in the Fuzzy Rule Base.
- Defuzzification: It converts the set of modified control out-put values into single point-wise (crisp) values and renormalizes the output onto its physical domain.

4. CONCLUSION

In this paper, we explain an introductory part of our project. We are using maximum input to the model, which are related to the UV intensity of water filter. In future, we will come up with the model which varies the UV intensity according to the measured input. So that it will result in maximum energy saving. For these purpose fuzzy logic controller is the best option to design a model.

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