IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering

Journal Européen des Systèmes Automatisés
Vol. 56, No. 3, June, 2023, pp. 451-458
Journal homepage: http://iieta.org/journals/jesa

Proposal of Coastal Flooding Scheme Using Smart Balloon Powered by Wind Turbine Generator

Sarah AL-Hussainy, Ali Abdul Razzaq Altahir*, Asseel AL-Gaheeshi

Electrical and Electronic Engineering Department, University of Kerbala, College of Engineering, Karbala 56991, Iraq

Corresponding Author Email: ali.altahir.g@uokerbala.edu.iq

https://doi.org/10.18280/jesa.560312

Received: 2 May 2023
Accepted: 10 June 2023

Keywords:
coastal flood mitigation, wind turbine generator, air compressor, rechargeable battery, DC motor control, smart balloon system, classical control scenarios, MATLAB simulation

ABSTRACT

Some coastal cities are sometimes exposed to floods, mainly caused by strong winds or earthquakes on the seafloor. This causes the water waves heading to the coastal cities to rise quickly, possibly destroying civilization. The proposed study will introduce an intelligent rubber balloon that automatically acts as a water repellent to absorb the momentum of water hammers from the sea. The proposed system has been energized by wind power energy. This enables the control of the bus voltage of the DC link. Sequential balloons could be arranged in such a matter to form a repel flood wall. Wind turbine generators could be used for charging the storage batteries. These batteries energize the smart control system and DC motors coupled with air pumps. These pumps are used to inflate the sequential air balloons. The theoretical models of the proposed system components have been simulated by MATLAB environment. Three DC motors are connected based on the master-salve mechanism, and the third is considered in standby mode. These motors are controlled by a model reference adaptive controller. The tracking speed between reference and measured speeds has been accomplished. Control of switching ON-OFF balloons using fuzzy logic control and classical control has been compared. After using several control scenarios for air pressure in balloons, it is observed that the best response is obtained using fuzzy logic control since it reduces the setting time and faster time response compared to the classical PID controller. Also, it was noticed that time response improved when using a PID controller instead of proportional or PD control scenarios, and the system dynamic response became acceptable.

1. INTRODUCTION

The proposed coastal flooding scheme using a smart balloon powered by a wind turbine generator is an innovative and sustainable solution to combat the challenges of rising sea levels and coastal flooding. This scheme will use a balloon equipped with a wind turbine generator, which will harness the power of the wind to generate electricity and then use this electricity to pump water from the coastal region into a reservoir. Smart balloon powered by wind turbine generators to absorb coastal floods is one of the interesting subjects according to the global market needs. The proposed system consists of several components to form an automatic dam. The procedure starts with wind turbines charging pre-equipped batteries after converting from AC to DC. After that, there is an electric motor connected to an air compressor. The electric motor is equipped with energy through the charged batteries. When the air compressor runs, it pumps the compressed air into storage tanks for storing compressed air, equipped under the ground to store the compressed air. When there is any increase in the wind speed from the normal speed, several sensors will be sensitive to that and then start filling several balloons through the input valve, allowing air to enter the balloons one by one to form a wall to protect the nearby areas. When the wind speed returns to normal, the air exits from the balloon through the outlet valve, and the balloon returns to its previous position in an underground trench. The control objectives of this study can be summarized as follows:

CO1: Speed control of the wind turbine generator system.

CO2: Speed control of DC motor using master-salve and model reference adaptive controller.

CO3: Suggest an efficient protocol for switching pressure sensors and air compressors to inflate sequential air balloons

CO4: Control of switching ON-OFF innovative balloon using Fuzzy Logic Control.

2. LITERATURE REVIEW

In many coastal communities, adaptation to climate change included tackling SLR and higher storm streams, and the vulnerability of the nearby coastal area to floods and erosion Significantly bared reduced by mangroves [1]. Natural disasters such as coastal floods and tsunamis devastate coastal areas and cause great damage to people's lives and property every year. Ecological balance and stability are the foundations of today's coastal protection. Saved the coasts by establishing beach forest shapes, known as the GB; it is a new strategy [2]. The air compressor must have a tank to store the air to be ready when the gate opens to fill the smart balloon with air. This system is safer and more accurate to use. Hourly bid and fitted curves are generated based on the optimal charging and discharging strategy [3]. It has also shown that the wind turbine hybrid system has saved smooth power output under variable wind speed conditions using compressed air as energy storage [4]. This study offers a primarily practical and cost-effective wind field analysis in this resource. Air compressors are directly connected to wind turbines to create compressed air. The combustion turbine generator system is continuously powered by compressed air stored beneath. This system is unique compared to the conventional compressed air energy storage method. During off-peak hours, a grid-powered air compressor is used; during peak hours, compacted air is cleared to operate the combustion turbine. Some potential benefits include reduction of greenhouse gas emissions, energy independence, cost-effectiveness, job creation and energy security if wind energy is a reliable and secure energy source, reducing the risk of power outages caused by disruptions in fossil fuel supply chains. The current study will focus on speed control of the wind turbine generator system, design of dynamic braking of wind turbine generator for the avoidance of sudden disturbances, speed control of DC motor using master- salve and model reference adaptive controller, suggest an efficient protocol for switching pressure sensors and air compressors to blow air balloon and control of switching ON-OFF innovative balloon using Fuzzy Logic Control. The structure of this paper is as follows: section 3 presents system requirements and basic mathematical relations, section 4 shows classical and smart control of the air pressure storage tank, section 5 discusses components of the smart structural balloon, in section 6 discusses simulation results of the proposed mechanism, and finally, the conclusion and remarks have been drawn in section 7. Alternative solutions should be considered to mitigate the damage caused by floods, and renewable energy sources like wind turbines should be promoted for sustainable electricity generation.

3. SYSTEM REQUIREMENTS AND BASIC MATHEMATICAL RELATIONS

3.1 Wind turbine generator formulation

Reduced energy delivery costs to the power system are the main goal of improvements in wind turbines. The generator system helps achieve this goal by converting the mechanical energy into electrical energy, which helps minimize energy costs. Because operating expenses (such as repair and maintenance) must also be considered, capital expenditures (like manufacture, transportation, and connection) are significant but inconclusive. It has been seen with permanent electromagnets changes in material costs affect changes in the optimal generator system. Decisions are influenced by uncertainty regarding these pricing movements. The location of the turbine's installation determines the optimal generator system because the energy generated is a function of wind speed [3]. Even though they need a device to orient the blades, horizontal-axis wind turbines are significantly more common. Compared to vertical aero generators, this kind has a higher aerodynamic yield.

Additionally, it contains suitable elements at the ground level and starts independently [4]. The ancestor wind is the foundation for horizontal-axis wind turbines. They consist of aerodynamically designed blades that resemble aeroplane wings. In this instance, the lift is produced to create a driving torque that causes rotation rather than to keep an aircraft in flight. In comparison to vertical wind turbines, this kind has gained ground. Additionally, they are less expensive, less susceptible to mechanical stresses, and more efficient due to the receiver's location several tens of meters from the ground [4]. The wind turbine power-speed characteristics are shown in Figure 1.

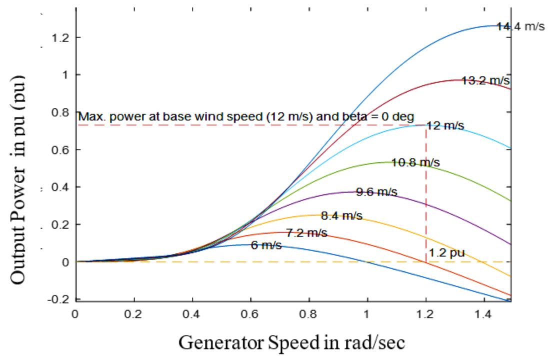

Figure 1. Wind turbine power – Speed Characteristics

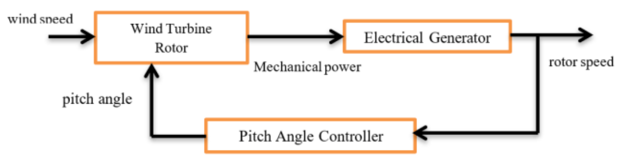

Figure 2. Block diagram for speed control of wind turbine

The turbine's mechanical output power can be calculated from the first equation. Figure 2 shows the wind turbine's dynamic response of output power measured in kW. The definition of parameters used in the system model is listed in the list of symbols.

$$P_m = c_p(\lambda, \beta)\frac{\rho A}{2} {V_w}^3 wind \tag{1}$$

It can calculate the turbine's performance coefficients from (2) and (3).

$$C_P = \frac{Extracted\ Power}{windPower} = \frac{P_{rotor}}{P_{wind}} \tag{2}$$

$$c_p(\lambda, \beta) = c_1\left(\frac{c_2}{\lambda_i} - c_3\beta - c_4\right)e^{\frac{-c_5}{\lambda i}} + c_6\lambda \tag{3}$$

$$\frac{1}{\lambda i} = \frac{1}{\lambda + 0.08\beta} - \frac{0.035}{\beta^3 + 1} \tag{4}$$

The tip speed ratio is:

$$\lambda = \frac{w_r * R}{V_w} \tag{5}$$

The swept area is:

$$A = \pi * R^2 \tag{6}$$

3.2 Modelling of the storage battery

As a backup power source, use lead-acid batteries. Small life, low, precise energy, and significant contamination are all disadvantages of lead-acid batteries [5]. They have invented two new models for proper diesel and hybrid battery systems. The proposed models are unique in that they incorporate the choice of turbine technology into the optimization process rather than standard parameters [6]. Control of the depth of individual emptying of cells and cell life is estimated regularly to ensure entirely cells in the package simultaneously reach the end of their useful life [7]. By connecting a three-phase dynamic load to the network, a PMSG is used to convert WE [8]. Using real-world wind farm data and a simplified battery energy storage system (BESS) model, simulations show that this control strategy performs great, closely tracking target transmission set points while keeping BESS's current and SOC within acceptable limits [9]. Lead-acid batteries are the most commonly used. However, they have a short cycle life and thus present a problem (usually 200-500 complete equivalent cycles). Depending on the energy smoothing approach used, compare several storage structures' performance to reduce gradient rate violations [10]. They also recommend using convective parameters to reduce performance degradation and prevent heat escape [11]. There are no liquids, and it does not depend on chemical reactions [12]. Deep-cycle batteries are made to store energy from a solar-wind hybrid system or a tiny wind turbine. They are made to have daily discharges that take them down to about 40% of their maximum capacity. The maintenance-free sealed AGM lead acid batteries are perfect for off-grid power systems and may be readily transported to a remote site because they are leak-proof. Figure 3 shows the electrical Equivalent circuit diagram for deep cycle battery. The following model will be formulated for calculating battery life:

$$Battery\ life(day) = \frac{Capacity(Ah)}{24\ h\ x\ I(Ah)} \tag{7}$$

$$Battery\ life(month) = \frac{Capacity(Ah)}{30\ day\ x\ I(Ah)} \tag{8}$$

$$Battery\ life(year) = \frac{Capacity(Ah)}{365\ day\ x\ I(Ah)} \tag{9}$$

$$Load\ current\ (Amps - Hour) = \frac{Total\ Load\ (W)}{battery\ Voltage\ (volts)} \tag{10}$$

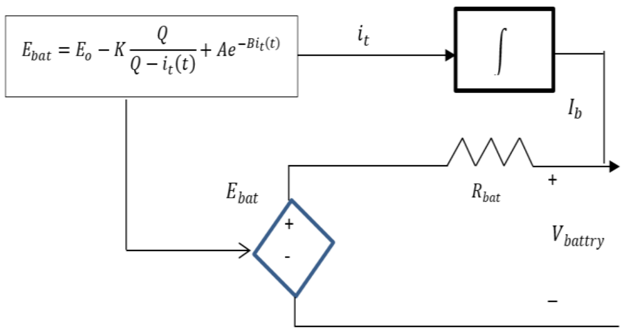

Figure 3. Equivalent circuit diagram for deep cycle battery

The terminal voltage of the battery, state of charge, instantaneous current and battery output current are formulated mathematically in the following:

$$v_{battery} = E_{bat} - R_{bat}I_{bat} \tag{11}$$

$$SoC = 100(1 - \frac{i_t}{Q}) \tag{12}$$

$$i_t(t) = \int_0^t I_b(t)dt, I_b = \frac{E_{bat}}{R_{bat}} - \frac{v_b}{R_{bat}} \tag{13}$$

3.3 Electrical motor modelling

There are many types of DC motors. It has been used separately excited DC motors because independently lowering the field current allows the DC motor to work above its base speed in the FWA. Switching the back EMF and forth can also change the speed direction. The air compressor needs a motor that synchronizes speed and torque to work. These gaskets also feature stators and rotors. The static portion of the component, which contains the field windings, is referred to as the stator. Armature coils or windings comprise the rotor, the rotating armature. A few field coils in a DC motor are stimulated individually and resemble shunt-wound field coils. In other DC motors, the power for the field and armature coils normally comes from the same source. A distinct excitement in their area of expertise is not required. However, in an independently excited DC motor, the armature and field coil are stimulated by a different supply. Field windings create the stator, the motor's static component. Used three separately exited DC motors and connected them using a master-salve method.
On the other hand, the rotating armature, or rotor, is made of armature windings or coils. The field coils of a dc motor that is independently stimulated are comparable to those of a DC motor [13]. Use the DC motor system model developed below [14].

$$L_I di_a = V - R_a i_a - R_b(i_a - i_f) - K_m \Phi_f(i_f)\omega \tag{14}$$

$$\frac{Jdw}{d_t} = K_m \Phi_f(i_f) i_a - B\omega - T_L \tag{15}$$

It has been considered that field resistance, R_f, stator resistance R_b, friction coefficient B, and load torque T_L are known in control speed. Field and armature windings are energized individually in a DC motor to create two different DC supply voltages. This motor contains, $I_a=I_L=I$. EMF was created using KVL [15] :

$$Ev = V - IRa \tag{16}$$

where, *Ra* is armature resistance, and *V* is primary voltage. The primary source is:

$$P = VI \tag{17}$$

Mechanical power created equals the sum of the power input to the armature and the power lost in the armature (Pm). Use model reference adaptive controller (MRAC) to control motor speed in which the tracking speed error between reference speed and actual rotated speed measured in (rad /sec) is calculated as follows:

$$e_\omega = \omega_{ref} - \omega_r \tag{18}$$

3.4 Air compressor modelling

Compressor air energy storage is a proven technology; several successful facilities worldwide have used it for nearly 30 years. Domestic diesel production systems with wind turbines could use CAES and direct air-capture CO_2 devices [16]. Hourly bid and fitted curves are generated based on the optimal charging and discharging strategy [17]. Additionally, it has demonstrated how using CAES allowed the WT hybrid system to preserve smooth power output under fluctuating wind speed situations [18]. The CH-CAES system's behaviour was evaluated using off-design simulations of crucial components with changing wind power [19]. The study used the sliding window statistical approach with deflection sequence to estimate the fault early warning threshold using a standard for air compressor failure assessment and alarm [20]. The Data is communicated between the device and the client or application using the MT-Connect standard as a communication mechanism [21]. With a top-down method, complete design technology analyzed safety and feasibility concerns before providing the foundation structure as the final step [22]. It can present an experimental and economic analysis of a large-scale CAES system with a wind turbine generator based on cost-effective standards [23]. Compressed air stays underground and is used continuously to energize the combustion turbine generator system [24]. There are many types of air compressors, and by studying the types of air compressors, we found that the best type of air compressor suitable for this system is the centrifugal compressor.

$$T_1(K) = T_1(c) + 273.15$$
$$c_p = 2 * e^{-13} * (T_1)^4 - 9 * e^{-10} * (T_1)^3 + e^{-6} * (T_1)^2 - 0.0005 * T_1 + 1.0595 \quad (19)$$

$$R = \frac{R(J/K * mol)}{air_{Molecular}Weight(\frac{kg}{kmol})}$$
$$\gamma = \frac{C_p}{C_p - R},\ k = \frac{\gamma - 1}{\gamma} \quad (20)$$

The pressure ratio $= \frac{p_2}{p_1}$. That is p_2 =pressure ratio*p_1. So, $T_2 = T_1 * (\frac{p_2}{p_1})^k$.

The work required to air compressor is:

$$W = C_p(T_2 - T_1) \quad (21)$$

And the Isentropic work is:

$$Work = \dot{m} * W \quad (22)$$

The compressor efficiency is:

$$\eta = \frac{Isentropic\ Work}{Actual\ Work} \quad (23)$$

4. CLASSICAL AND SMART CONTROL OF THE AIR PRESSURE STORAGE TANK

Various techniques were used to control the air pressure tank, which stores and holds the compressed air.

4.1 Proportional controller

Proportional controllers are employed when the first-order system with single energy storage is stabilized. It reduces the steady state inaccuracy. Despite the reduction, proportional control will completely eradicate the steady state inaccuracy. Raising proportional gain results in faster dynamics, broader frequency band satisfaction, smaller amplitude and phase margin, and increased noise sensitivity. Oscillation may also happen if proportional control is applied too firmly and there are delays or slow times. The number of lags makes the problem worse (higher-order). Additionally, it directly intensifies process noise [15].

4.2 Proportional integrator controller

The future error in the system response can be anticipated using a PD controller, which improves control and aims to promote system stability. The derivative is derived from the output response of the system variable rather than from the error signal to prevent the impact of a change in the value of the error signal. D mode is created proportionate to the change in the output variable to avoid abrupt changes in the error signal. D command is not employed since D directly increases process noise [15].

4.3 Proportional integrator derivative controllers

The Proportional Integrator Derivative (PID) controller presents the top command dynamics because it has no fluctuations, a fast response (low rise time), zero steady-state error, and higher stability. In addition to the PI controller, a derivative gain component must be utilized to stop oscillations and overshoots in the output reaction of the system. The proportional integrator derivative controller's adaptability to higher-order processes involving multiple energy storage units is one of its key qualities [15].

4.4 Fuzzy logic control controllers

Fuzzy sets of objects in which smooth conversion from membership to non-membership rather than abrupt serve as the foundation for FLC. Therefore, fuzzy set boundaries can be hazy and imprecise, which helps estimate models. The truth values of variables in FL, a type of many-valued logic, can be a real number bounded between 0 and 1. This approach discusses partial truth, where the truth value might range from T to F. Contrarily, in Boolean logic, variables' truth values can only be 0 or 1. Based on the fact that decisions are frequently made utilizing Fuzzy and non-numerical information. Fuzzy logic was developed. Fuzzy models or sets are examples of mathematical representations of uncertainty and imprecise data. These models can distinguish, signify, operate, understand, and exploit hazy and imprecise truths and data.

The reason for using fuzzy logic is the system is adaptable and changes online or offline. Like that, fuzzy logic systems are simple to build. FLC offers solutions to complex problems. FLC is easy to understand. Fuzzy logic can handle several inputs and use precise functions to arrive at a choice. FL system is easy to design and has a basic structure. FLC requires less physical space. FL system is similar to human thinking, making decisions easily and allowing one to handle difficult issues easily.

5. COMPONENTS OF SMART STRUCTURAL BALLOON

In its simple form, the invention may consist of the following components: A reinforced oval balloon fixed from the lower end in an underground trench. An underground trench covered with a movable steel roof. A steel rope to tie the inflated balloon to a support base during coastal flood waves. A lower or radial base increases the stability of the foundation.

5.1 Electrical components for ballon

Current meter to measure the velocity of the current water installed in an advanced position in the sea to send a signal to the control panel in emergency cases. Wind turbines operate the electric generator to charge the batteries. A battery powers the electric motor to operate the air compressor. An air tank stores the compressed air needed to fill the balloon in emergencies. - outlet and inlet - exit valves for cavity, air entry, and exit. Figure 4 shows smart structural and electrical components. The Smart Balloon will be made of lightweight, durable materials resistant to harsh weather conditions. It will be tethered to the ground, and its height will be adjusted according to the wind direction and speed, ensuring maximum energy generation. The wind turbine generator will be placed at the top of the balloon, where it will capture the strongest wind currents.

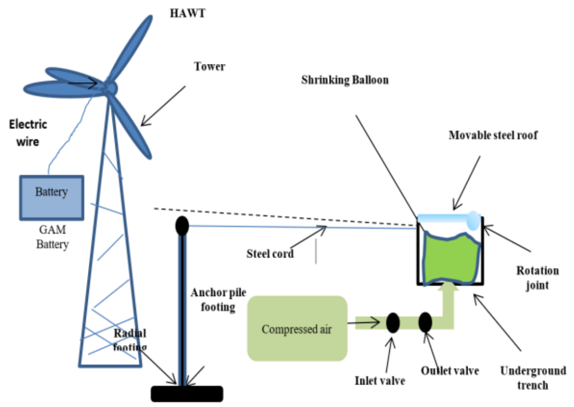

Figure 4. Smart structural and electrical components

5.2 Floods waves repelling mechanism

The balloon, in the normal state, is in a deflated state and stored in an underground trench that extends along the seashore, which is usually covered with a steel roof to hide it from view and direct sunlight, in addition to normal use on the surface of the earth in coastal beaches for other purposes such as roads or tourism. In this case, the system is qualified to be ready for emergencies. The batteries are fully charged and can start the air compressors immediately, even though there is enough compressed air in the air tanks to fill the balloon in an emergency, as shown in Figure 5.

Table 1. Aerodynamic parameters of the proposed system

Parameters	Value
Specified Distance(m)	1000m
The volume of the tank (V_{tank})	1450.797m^3
Number of balloons used for the specified distance	100
Mass(m)	1637.231kg
Mass flow rate($\dot{m}$)	3.34(kg/s)
The expected height of the water wave (h_p)	9.25

When the flood waves start heading to the coast at a speed exceeding the usual seawater current, the advanced current meter sends a signal to the electrical control panel. The air intake valves begin to allow air to enter the balloon to support the chemical pressure and to make the balloon inflate with the pressures required to meet the flood's force, as shown in Figure 5. This figure shows how the steel rope holds the balloon vertically to resist and absorb incoming waves. Table 1 lists the aerodynamic parameters of the proposed system.

6. SIMULATION RESULTS OF THE PROPOSED MECHSNISEN AND DISCUSSION

In this study, A tank air compressor – driven by a DC motor provided by wind power was constructed in a MATLAB R2022a environment. Table 2 lists the technical factors of DC motors. Table 3 clarifies the tuning parameters of the model reference adaptive controller and the classical PID controller for the air pressure tank. Table 4 lists the most important rules used in FLC. Figure 6 shows the responses for speed control of the wind turbine, extracted power and pitch angle correction. Figure 7 shows the responses of rechargeable batteries, such as state of charge SOC, terminal voltage, passing current and the power provided for DC motors.

Table 2. Technical parameters of DC motor

Parameters	Value
Damping	0.01 N.s/m
Inertia	0.27 kg.m^2
Back EMF	0.1 V
Armature Resistance	10 Ω
Armature Inductance	0.001 H

Table 3. Parameters of MRAC and PID control for air pressure tank

Parameters	Value		
Controller parameters of DC Motor using MRAC			
γ	0.01		
θ	0.1422		
type	K_p	K_i	K_d
Controller of DC motor	700	3015	39
P	6	-	-
PD	5	-	2
PID	5	4	2

Table 4. Most important rules used in FLC

State No.	Air Pressure	Rate of Air Pressure	Inlet Valve Open
1.	Low	Negative	Close fast
2.	Medium	Zero	Close slow
3.	High	Positive	No change
4.	-	-	Open slow
5.	-	-	Open fast

6.1 Results for Horizontal –Axis wind turbine control

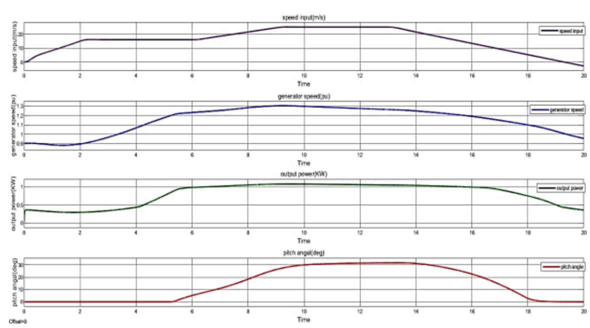

Figure 5. Responses for speed control of the WTG extracted power and pitch angle correction

Figure 5 presents responses for speed control of the wind turbine generator, extracted power, and pitch angle correction during wind speed exceeding the rated speed of the wind turbine.

6.2 Results for rechargeable battery control

Figure 6 shows the responses of the rechargeable battery for SOC, terminal voltage, passing current and the provided power, respectively.

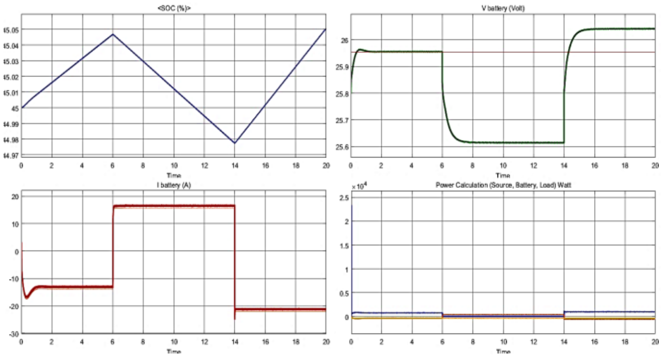

Figure 6. Responses of rechargeable battery for SOC, terminal voltage, passing current and the provided power

6.3 Results for electrical motor control

Three DC motors are used and connected based on the master-salve mechanism, as shown in Figure 7, coupling with MRAC for DC motors used in this study. It should be emphasized that the tracking speed control is accurate for the first, second and third of the DC motor, as illustrated in the Figures 8 and 9, 10, respectively.

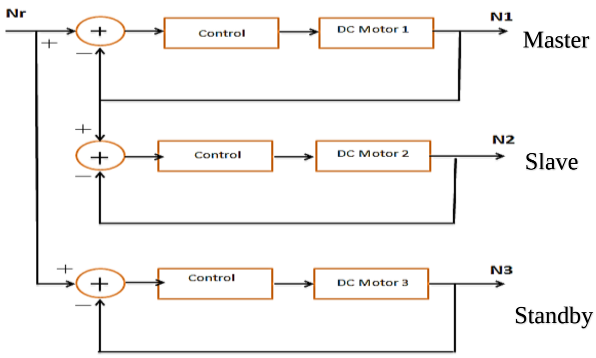

Figure 7. Block diagram of master-Slave control of DC motors

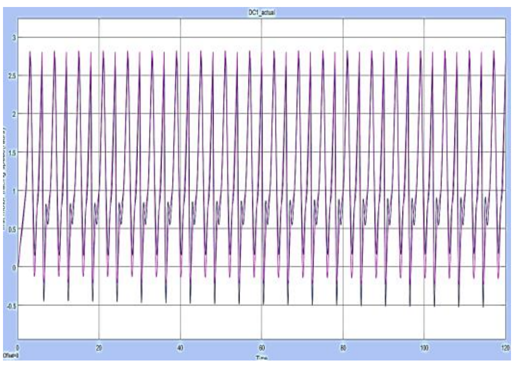

Figure 8. Tracking speed of the DC motor for the first motor

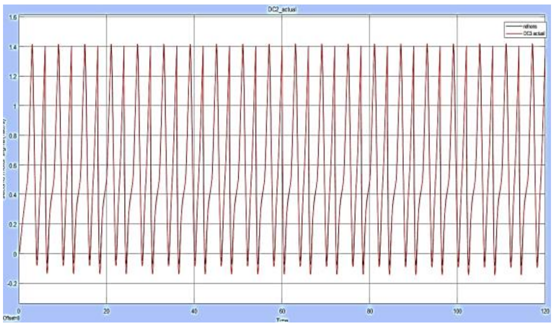

Figure 9. Tracking speed of the DC motor of the second motor

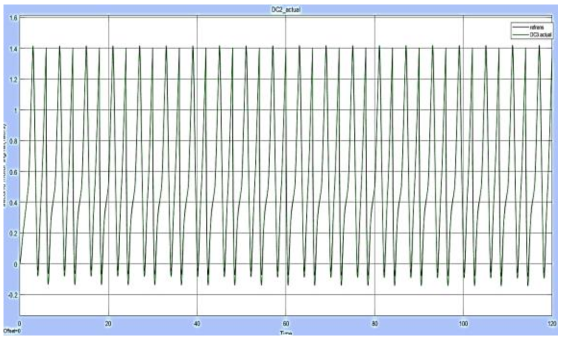

Figure 10. Tracking speed control of the DC motor of the third motor

By modifying the control parameters, Model Reference Adaptive Control (MRAC) seeks to make the controlled system behave as a desired reference model. The controller is continuously adjusted based on the discrepancy between the output of the system and that of the reference model via a feedback loop. MRAC employs adaptive mechanisms to estimate and update the model parameters of the controlled system. Based on the discrepancy between the output of the system and that of the reference model, it adjusts the controller parameters in real-time systems with known models. It requires accurate knowledge or estimation of the system dynamics, which can be challenging for highly complex or uncertain systems. Stability analysis in MRAC typically involves examining the convergence properties of the adaptive parameter estimation and control laws. MRAC can achieve excellent tracking performance when the system model is accurately known or can be effectively estimated. However, it may suffer from model mismatches and disturbances.

6.4 Results control of air pressure compressor

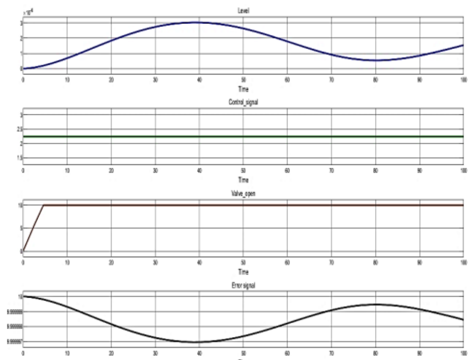

Figure 11. Proportional control for air pressure compressor

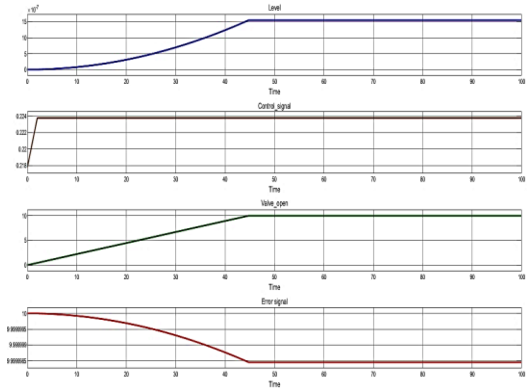

Figure 12. Proportional derivative control for air pressure compressor

Figure 11 shows air pressure proportional control from simulation results, whilst Figure 12 clarifies proportional derivative control for air pressure compressor (Figure 13). illustrates PID control for the air pressure compressor.

Fuzzy logic control is used to control the air pressure level. Two inputs have been used, air pressure and rate of air pressure, and one output inlet valve open for designing the fuzzy logic controller, as shown in Figure 14. Figure 15 shows responses using FLC for air compressors.

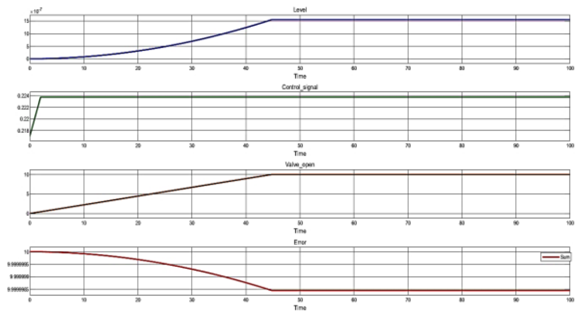

Figure 13. PID control for air pressure compressor

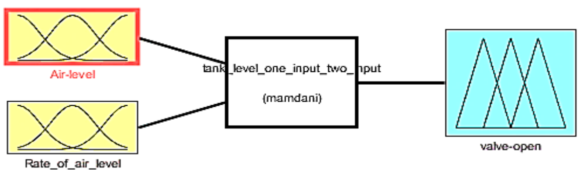

Figure 14. Input – Output signals of air pressure tank provided to FLC

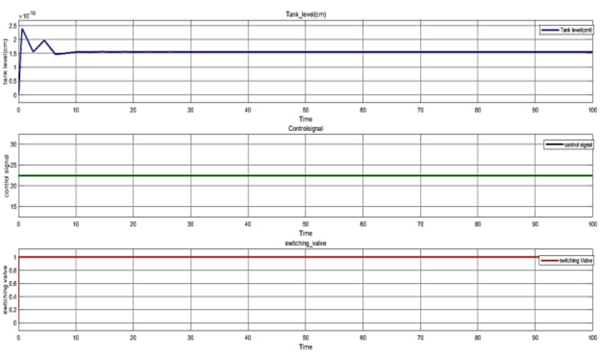

Figure 15. Responses for fuzzy logic controller for air compressor

It is observed that the response improved in the PID, the system became faster, and its response improved. The above results noted that the best response was obtained when using FLC since it reduced the setting time and was also faster.

7. CONCLUSIONS AND REMARKS

This paper's concept of using a smart balloon powered by a wind turbine generator system to absorb coastal floods seems interesting. Its low cost distinguishes it from other types of dams, and the ability to manufacture them locally and transfer them from one location to another. The membranes of these dams are characterized by the possibility of establishing and replacing easily and very quickly. It is characterized by safe operation. It is characterized by the absence of the need for driving mechanisms such as hydraulic cylinders, electric motors or chains, which need continuous maintenance. It is not affected by earthquakes and tremors. The work of an air compressor can be regulated to fill the tank with compressed air. The fuzzy logic algorithm is the best control response and PID controller, faster than proportional. Because the fuzzy logic reduces the rehearsal and settling time during the simulation, it also speeds up the system's response and reduces the error rate. It is challenging to control the parameter values in a conventional PID controller and obtain good, appropriate characteristics. Also, it can control torrents that occur due to floods or floods. It is applied to protect the border cities from the risks of torrential rains coming from the highlands. Alternative solutions should be considered to mitigate the damage caused by floods, and renewable energy sources like wind turbines should be promoted for sustainable electricity generation. The coastal flooding scheme using a smart balloon powered by a wind turbine generator has several advantages over traditional flood protection measures. It is a sustainable solution that uses renewable energy, reducing carbon emissions and dependence on non-renewable energy sources. It is also cost-effective and requires minimal maintenance, making it a viable option for developing countries and regions. In conclusion, the proposed coastal flooding scheme using a smart balloon powered by a wind turbine generator is a novel and sustainable solution to mitigate the impacts of coastal flooding caused by rising sea levels. With its innovative technology and renewable energy source, this scheme has the potential to revolutionize flood protection measures worldwide.

REFERENCES

[1] Motamedi Nezhad, A., Farhi Moghadam, M., Davoudi, L. (2017). Effect of coastal forest on solitary breaking waves forces absorption in sloping coasts. Irrigation Sciences and Engineering, 40(2): 251-263. https://doi.org/10.22055/jise.2017.13183

[2] Blankespoor, B., Dasgupta, S., Lange, G.M. (2017). Mangroves as a protection from storm surges in a changing climate. Ambio, 46(4): 478-491. https://doi.org/10.1007/s13280-016-0838-x

[3] Polinder, H., Ferreira, J.A., Jensen, B.B., Abrahamsen, A.B., Atallah, K., McMahon, R.A. (2013). Trends in wind turbine generator systems. IEEE Journal of Emerging and Selected Topics in Power Electronics, 1(3): 174-185. https://doi.org/10.1109/JESTPE.2013.2280428

[4] Yahyaoui, I., Cantero, A.S. (2018). Modelling and characterization of a wind turbine emulator. In Advances in Renewable Energies and Power Technologies, pp. 491-508. https://doi.org/10.1016/B978-0-12-812959-3.00016-2

[5] Guo, B.X., Wu, J., Qun, J., Han, Q.J. (2017). The lithium-ion battery standby power of wind turbine pitch system. Energy Procedia, 105: 3539–3544. https://doi.org/10.1016/j.egypro.2017.03.812

[6] Rakhshani, E., Mehrjerdi, H., Iqbal, A. (2020). Hybrid wind-diesel-battery system planning considering multiple different wind turbine technologies installation. Journal of Cleaner Production, 247: 119654. https://doi.org/10.1016/j.jclepro.2019.119654

[7] Babazadeh, H., Gao, W., Duncan, K. (2012). A new control scheme in a battery energy storage system for wind turbine generators. In 2012 IEEE Power and Energy Society General Meeting, pp. 1-7. https://doi.org/10.1109/PESGM.2012.6345722

[8] Sakipour, R., Abdi, H. (2020). Optimizing battery energy storage system data in the presence of wind power plants: A comparative study on evolutionary algorithms. Sustainability, 12(24): 10257. https://doi.org/10.3390/su122410257

[9] Zheng, Y., Hill, D.J., Meng, K., Luo, F.J., Dong, Z.Y. (2015). Optimal short-term power dispatch scheduling for a wind farm with a battery energy storage system. IFAC-PapersOnLine, 48(30): 518-523. https://doi.org/10.1016/j.ifacol.2015.12.432

[10] Mannelli, A., Papi, F., Pechlivanoglou, G., Ferrara, G., Bianchini, A. (2021). Discrete wavelet transforms for the real-time smoothing of wind turbine power using li-ion batteries. Energies, 14(8): 2184. https://doi.org/10.3390/en14082184

[11] Jung, W., Jeong, J., Kim, J., Chang, D. (2020). Optimization of a hybrid off-grid system consisting of renewables and Li-ion batteries. Journal of Power Sources, 451: 227754. https://doi.org/10.1016/j.jpowsour.2020.227754

[12] Mandic, G., Nasiri, A., Ghotbi, E., Muljadi, E. (2013). Lithium-ion capacitor energy storage integrated with variable-speed wind turbines for power smoothing. IEEE Journal of Emerging and Selected Topics in Power Electronics, 1(4): 287-295. https://doi.org/10.1109/JESTPE.2013.2284356

[13] Mohammed, A.J. (2013). Speed control for separately excited dc motor drive (SEDM) based on an adaptive neuro-fuzzy logic controller. Eng. & Tech. Journal, 31(2): 277-295. https://doi.org/10.30684/etj.31.2A.6

[14] Zhou, J., Wang, Y. (2002). Adaptive backstepping speed controller design for a permanent magnet synchronous motor. IEE Proceedings-Electric Power Applications, 149(2): 165-172. https://doi.org/10.1049/ip-epa:20020187

[15] Sena, T., Semih, Y., Semih, G. (2019). Discrete-time control systems recitation report, middle east technical university electrical and electronics engineering department.

[16] Vézina, G., Brouillette, M. (2021). Assessment of an integrated direct CO2 air capture system using wind power with compressed air energy storage in northern regions. In Proceedings of the 15th Greenhouse Gas Control Technologies Conference, pp. 15-18. https://doi.org/10.2139/ssrn.3816112

[17] Hosseini, A., Sadeghi Yazdankhah, A. (2021). Hybrid robust-stochastic bidding strategy for integrated power to gas and compressed air energy storage systems coordinated with the wind farm. Journal of Energy Management and Technology, 5(4): 45-56. https://doi.org/10.22109/jemt.2021.260726.1267

[18] Krupke, C., Wang, J., Clarke, J., Luo, X. (2016). Modelling and experimental study of a wind turbine system in hybrid connection with compressed air energy storage. IEEE Transactions on Energy Conversion, 32(1): 137-145. https://doi.org/10.1109/TEC.2016.2594285

[19] Zhao, P., Wang, P., Xu, W., Zhang, S., Wang, J., Dai, Y. (2021). The survey of the combined heat and compressed air energy storage (CH-CAES) system with dual power levels turbomachinery configuration for wind power peak shaving based spectral analysis. Energy, 215: 119167. https://doi.org/10.1016/j.energy.2020.119167

[20] Cui, C., Lin, W., Yang, Y., Kuang, X., Xiao, Y. (2019). A novel fault measure and early warning system for air compressor. Measurement, 135: 593-605. https://doi.org/10.1016/j.measurement.2018.12.029

[21] Verma, N.K., Dev, R., Dhar, N.K., Singh, D.J., Salour, A. (2017). Real-time remote monitoring of an air compressor using connect standard protocol. In 2017 IEEE International Conference on Prognostics and Health Management (ICPHM), pp. 109-116. https://doi.org/10.1109/ICPHM.2017.7998314

[22] Ammal Dhanalakshmi, M., Deivasundari, P. (2021). Modular compressed air energy storage system for 5kw wind turbine: A feasibility study. Clean Technologies and Environmental Policy, 23(7): 2201-2212. https://doi.org/10.1007/s10098-021-02127-7

[23] Ahmed Gouda, E., Abd-Alaziz, A., El-Saadawi, M. (2021). Economic and experimental study of the hybrid power system of compressed air energy storage with photovoltaic array and wind turbine generator. MEJ-Mansoura Engineering Journal, 46(2): 32-41. https://doi.org/10.21608/BFEMU.2021.180698

[24] Nguyen, T.V. (2014). Integration of compressed air energy storage with a wind turbine to provide an energy source for a combustion turbine generator. In IEEE PES Innovative Smart Grid Technologies, Europe, pp. 1-5. https://doi.org/10.1109/ISGTEurope.2014.7028747