Gravity energy storage libya

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Different energy storage systems have been studied and developed over the last two decades. Most of the systems introduced were the electrical, chemical, electrochemical, thermal, and mechanical energy storage9,10,11. Mechanical systems, such as flywheel energy storage (FES)12, compressed air energy storage (CAES)13,14, and pump hydro energy storage (PHES)15 are cost-effective, long-term storage solutions with significant environmental benefits for small- and large-scale renewable energy power plants to overcome energy generation fluctuation16.

According to20, the first closed hydraulic circuit was developed by a company called Gravity Power. The main idea was to pump water from a low-pressure side to raise a piston in a closed hydraulic circuit; in this case, this is called the storage phase. When there is a need to recover the stored energy, the piston is allowed to descend by opening a valve, allowing water to flow through a hydraulic turbine and generate electricity. According to Heindl21, the efficiency of the round-trip gravitational energy storage system can reach more than 80%.

On the other hand, valuable efforts were made to avoid the use of heavy pistons and improve system performance25. Botha and Kamper26 investigated a waterless gravity energy storage system with a wire rope hoist and drive train technology up to 90% efficiency27,28.

On the other hand, the statistical design of experimental methods provides a straightforward and equally efficient approach. The evolutionary operation, factorial, regression, response surface, and Taguchi methods are the most used for experimental design34,35,36. Ibrahim et al.37 presented Taguchi optimization of tribological behaviors of composite materials. They concluded that Taguchi and analysis of variance (ANOVA) techniques are promising for predicting tribological behavior and can then be used to guide the design and implementation of tribological materials.

Taguchi"s method is superior to other optimization methods because it allows simultaneous optimization of multiple factors. Furthermore, fewer experimental trials can yield more quantitative information. Taguchi"s method has been used in various fields, including renewable energy generation and energy storage systems38,39,40,41.

This paper presents a novel comprehensive model that predicts and optimizes the most influencing parameters on the performance of gravitational energy storage systems. The simulated model using

MATLAB-SIMULINK was created and validated against experimental data from the literature before applying the statistical approach. The Taguchi method was then used to predict the contribution of design parameters to system performance and to determine the best combination of parameters to maximize system performance due to its simplicity and dependability.

This research was divided into six stages. The first stage was performing the mathematical modelling of the system by applying the governing equations. The second stage was the development of a virtual simulation of the system using MATLAB/Simulink. This simulation is used to investigate the system performance.

The equations describing the systems are applied to numerically investigate the parameters that can significantly affect a gravity energy storage system. As there are different interactions between system components, the motion of the model was built by adopting Berrada et al. in22,30 technique, with some modifications over the main assumptions and strategies.