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Green solution for power generation by adoption of adiabatic CAES system

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ABSTRACT

In this work the use of compressed air energy storage with using the high compressor discharge temperature is discussed and analyzed. Performance is calculated for adiabatic (CAES) and compared with conventional systems. The operating variables in this study are discharge air mass flow ($\dot{m}_a$), ambient air temperature (T_a) and overall pressure ratio (Rc). The effect of these variables on the generated power ($\dot{W}_{gen}$), energy ratio (ER), efficiency (η), and other performance parameters is evaluated.

The results showed that adiabatic CAES offered relatively high energy storage efficiency, compared with conventional CAES technology.

1. Introduction

Some compressed air energy storage plants (CAES) are either fully developed, or partly developed whereas others are at the conceptual stage. Utilities usually demand peak load plants to be readily available for operation and exhibit a high reliability and availability in addition to simple methods of control and maintenance.

Compressed air energy storage plants are being recognized as technically feasible and economically attractive for load management [1,2]. It has similar advantages to peak load gas turbine power plants and pumped storage scheme [3,4]. Performance analysis of CAES with humidification was also carried out and compared with CAES [5].

On a utility scale, compressed air energy storage (CAES) is one of the technologies with the highest economic feasibility which may contribute to creating a flexible energy system with a better utilization of fluctuating renewable energy sources [5,6].

CAES is a modification of the basic gas turbine (GT) technology, in which low-cost electricity is used for storing compressed air in an underground cavern. The air is then heated and expanded in a gas turbine in order to produce electricity during peak demand hours. As it derives from GT technology, CAES is readily available and reliable [7].

Three independent computer-based methodologies for identifying the optimal operation strategy for a given CAES plant were described in Ref. [8]. The optimal strategy is defined as the one which will provide best business-economic net earnings for the plant. All three methodologies have identified the same operation strategy as the optimal one [8].

A comprehensive review of compressed air energy use, savings, and payback period and energy efficient strategies is given in detail in Ref. [9]. Unfortunately, “conventional” CAES plants still depend on the combustion of gas, because the released air must be heated prior to expansion. This also inherently limits the storage efficiency of the overall process. Because of this, and as a response to developments in terms of fuel prices and CO_2 certification, the so-called *Adiabatic* CAES concept seeks to overcome these drawbacks, representing a locally emission-free, pure storage technology with high storage efficiency [10].

The optimal CAES/electricity system combination that minimizes the excess electrical-production (EEP) was studied, defined, and found, then the CAES plant capacity and the optimal wind-power penetration that could fully eliminate the EEP and condensing power production, was determined [11].

Adiabatic plant, which is one of the more promising green solutions, offered relatively high energy storage efficiency [12]. Recent studies suggest that new thermal energy storage (TES) technology, together with improvement in the compressor and turbine systems might make so-called Advanced Adiabatic CAES (AA-CAES), economically viable [13,14]. One such AA-CAES concept

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