Multi-Purpose Simulation and Testing Model Of the (Electronic Gas Turbine Control Unit) (EGTCU)

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ABSTRACT

This paper describes a modified modeling and simulation of the measurement and control system of the single shaft Gas Turbine (GT). This GT is used in electrical power generation in Khalda Petroleum Company. The main objective of this paper is to obtain a multi-purpose controller modeling and simulation that can be used in future testing. This controller controls the GT under heavy disturbance; considering the monitored variable is the mechanical torque. That is to obtain a general GT controller which can drive either a compressor or a generator. Then a testing procedure is done to test the Electronic Gas Turbine Control Unit (EGTCU). The system response and stability are considered to modify controller parameters and validate the controller before installation in real gas turbine system.

Keywords: Controller, Electronic Gas Turbine Control Unit (EGTCU), Gas Turbine (GT), Gas Turbine Simulation, System Response

INTRODUCTION

There is a large number of gas turbines (GT’s) in service all over the world. GT’s are widely used in aircraft engines, power generation and in various industrial applications. GTs are also used in oil and gas applications in power generation and in compression stations. That is because of the relatively short commissioning time, quick response capabilities and its high efficiency (Cohen, Rogers, & Saravanamutto, 1996; Giampaolo, 2006). GTs have been utilized
in many different capacities: as peaking units, base load units, part of a combined cycle... etc. Because of high efficiency requirements the testing models are required. That needs creating accurate simulation models. These models must be as real systems as possible. Most efforts before are done to simulate GT main components with simplified control system and no simulation for real measurement ways (Cigre Task Force C4.02.25, 2008; Hamarash, 2008; Schobeiri, Attia, & Lippke, 1994; Wanik & Erlich, 2009; Sheng, 2008; Crosa, Pittaluga, Trucco, Beltrami, Torelli, & Traverso, 1998; Kim, Song, Kim, & Ro, 2001; Badmus, Eyeker, & Nett, 1995; Rowen, 1983; Hannett & Khan, 1993; Hajagos & Berube, 2001; Working Group, on Prime Mover, & Energy Supply Models, 1994; Working Group on Prime Mover and Energy Supply Models, 1991; Working Group on Prime Mover and Energy Supply Models, 1992; Liu, 2003; Baba & Kakimoto, 2003). The main purpose in the proposed model is to achieve a more accurate multi-purpose simulation model. The proposed model offered a modification in the exhaust temperature measurement system; it also contains a modification in control systems to obtain flexible controllers.

These modifications are near to the real system exist in the Solar Turbine™ single shaft gas turbine Centuar40™ that installed in Khalda Petroleum Company in Egypt (www.solarturbines.com). In this model the rest of the GT system is simulated by computer system based on previous models. It contains the main components, controllers and measurement subsystems.

Considering that the main GT output is the mechanical torque. The output mechanical torque is the main variable to drive a generator or a compressor; also any applied disturbances on the generator or the compressor will make disturbance on the torque. By applying disturbances on the mechanical torque that will represent frequency drops and load variations in the generator or load changes in the compressor; so this measurement and the control system model are used for multi - purposes as they are suitable for both compressor drives and generator drives. This test model will reduce both time and cost of development. We will see how good measurement and control systems will improve the GT performance; and make it immune to disturbances. An outline of a previous work is proposed in the second section. In the third section the detailed simulated GT model components are explained. Fifth and sixth Sections explain model tests and discuss simulation system results. The seventh Section discusses the results and conclusions. Eighth Section contains appendixes and tables.

PREVIOUS WORK

In this section previous works are described. There are two types of heavy duty single shaft gas turbine models: Physical models and reduced thermodynamic models that are widely used in control system studies.

Physical Models

Physical models type derives the model directly from dynamics and physical thermodynamics properties and laws. Models involve utilizing laws governing thermodynamic behavior in the Brayton cycle (Cohen, Rogers, & Saravannamutto, 1996; Dixon, 1998) along with some simplifying assumptions to obtain the differential equations representing the dynamics and GT behavior. These laws are conservation of mass, conservation of power and conservation of energy (Schobeiri, Attia, & Lippke, 1994; Wanik & Erlich, 2009; Sheng, 2008; Crosa, Pittaluga, Trucco, Beltrami, Torelli, & Traverso, 1998; Kim, Song, Kim, & Ro, 2001). Other authors (especially those having a mechanical engineering background) utilize physical laws as well as thermodynamics laws in order to derive the equations representing GT dynamics (Schobeiri, Attia, & Lippke, 1994). These models are widely used in thermodynamics study or mechanical design studies; as different components of the GT such as ducting, compressors, combustors and air blades are modeled (Schobeiri, Attia, & Lippke, 1994;
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