Multi Area Hydro Thermal Power System With Redox Flow Battery Considering Tandem And Cross Compund Turbine

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Abstract- *The design of load frequency control system plays a vital role in automation of power system. This paper proposes a sophisticated application of Redox flow batteries coordinated with SSSC. Redox flow battery is used in both the area of the system, which converts electrical energy into chemical energy, that is used to meet the sudden requirement of real power load and hence very effective in reducing the peak over shoot. Ziegler Nichols method is used to tune the gain value of PI controller. In order to improve thermal efficiency higher pressure and higher temperature steam conditions are gaining attention by including tandem and cross compound turbine. Simulation study reveal the effectiveness of the SSSC and redox units, especially in terms of overshoots, undershoots and settling time, thereby improving the effectiveness of deregulated power system.*

I. INTRODUCTION

Energy is the basic necessity for the economic development of a country. Many functions necessary to present-day living grind to halt when the supply of energy stops. Real or active power control is one of the most important control actions to be performed during normal operation of the system to match the system generation with the continuously changing load, in order to maintain the constancy of system frequency to a tolerable limit [2]. The frequency of a power system is dependent entirely upon the speed at which the generators are rotated by their prime mover. All prime movers, whether, they are steam or hydraulic turbines are equipped with speed governor which are purely mechanical speed sensitive devices, to adjust the gate or control valve opening for constant speed. So the frequency of the system can be varied by varying the speed of the turbine. The function of load frequency control on a power system becomes one of changing the control value or gate openings of the prime movers, as a function of load variations in order to hold the system frequency constant. The real power in a power system is being controlled by controlling the driving torque of the individual turbines of the system. By controlling the position of the control valve or gate, we can exert control over the flow of high pressure steam or water through the turbine. Tandem single reheat turbine and cross compound reheat turbine is proposed in this paper to improve the turbine efficiency. Non-linearities like governor dead bad and generation rate constraint is incorporated with the system, which gives more oscillation in the system. Redox unit reduce the oscillation and yields better performance.

II. MULTI AREA SYSTEM INVESTIGATED

The transfer function model of two area hydro thermal power system with tandem and cross compound reheat turbine, boiler dynamics, SMES, SSSC and Redox unit is shown in the fig.1. The system is also incorporated with governor dead band and generation rate constraint. Proper assumptions and approximations made to linearize the mathematical equations which describe the system and transfer function model. The system has been designed for nominal system frequency [3].

A. Tandem Reheat Turbine

This assembly consists of four stages of all in line on the same shaft but can have several casings [4]. The superheated steam enters the high pressure stage (HP) where it expands through the small diameter rotor blades before exiting and being returned to the boiler. In the boiler the steam is superheated and again and is directed to the intermediate pressure stage (IP). Here it expands through large diameter rotor blades exiting to the low pressure turbines in the final stage, there are two identical sets of low pressure turbines. The steam expands through both of the LP turbines by being drawn into the vacuum condenser.

B. Cross Compound Reheat Turbine

In a cross compound steam turbine the super-heated steam enters the high pressure stage, expanding through the rotor blades before exiting to the intermediate pressure stage, both turbine rotors being on the same drive shaft. This HP/IP turbine rotates at 3600 rpm during a two pole generator. The exiting steam now crosses over from the IP stage into the low pressure turbine, where it expand through the rotor blades, driving its own shaft and giving up the last of its energy before being drawn into the vacuum condenser.

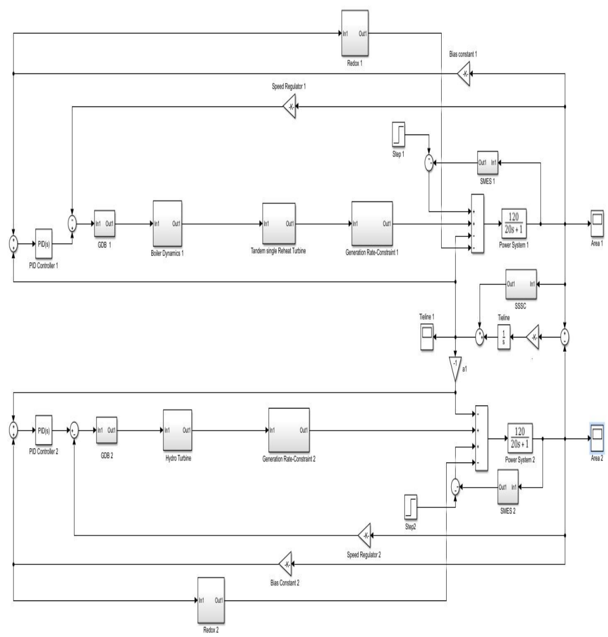

Figure 1. Transfer Function Model of Two Area Hydro Thermal Power System for Proposed Magnetic Storage Unit

C. Super Conducting Magnetic energy Storage

Many kinds of stabilizers have been proposed to improve the stability of a synchronous generator. The super conducting magnetic energy storage (SMES) is designed to store electric energy in the low loss super conducting coil. Power can be absorbed or released from the coil according to the system requirement [1]. The control is performed by changing the firing angle of the converters in the SMES unit, which rapidly moves the D.C output voltage up or down in order to achieve the desired power interchange.
The gate turn off (GTO) converters makes it possible for the SMES unit to operate in four quadrant modes. However the effective use of the SMES unit greatly depends on its control strategy. Fast acting energy storage device, SMES can effectively damp out power frequency and tie line power oscillations caused by small load disturbances.

III. STATIC SYNCHRONOUS SERIES COMPENSATOR

The two-area interconnected power system with a configuration of SSSC used for the proposed control design. It is assumed that a large load with rapid step load change has been experienced by area1. This load change causes serious frequency oscillations in the system. Under this situation, the governors in an area 1 cannot sufficiently provide adequate frequency control. On the other hand, the area 2 has large control capability enough to spare for other area. Therefore, an area 2 offers a service of frequency stabilization to area 1 using the SSSC. Since SSSC is a series connected device, the power flow control effect is independent of an installed location.

In the proposed design method, the SSSC controller uses the frequency deviation of area 1 a local signal input. Therefore the SSSC is placed at the point near area1. Moreover the SSSC is utilized as the energy transfer device from area 2 to area1. As the frequency fluctuation in area 1 occurs, the SSSC will provide the dynamic control of the tie-line power by exploiting the system interconnections as the control channels and the frequency oscillation can be stabilized [6].

IV. REDOX FLOW BATTERY

The Redox Flow Battery is implemented in the power system. A sulfuric acid solution containing vanadium ions is used as the positive and negative electrolytes, which are stored in respective tanks and circulated to battery cell [5]. The Redox Flow Batteries offer the following features, and are suitable for high capacity systems that differ from conventional power storage batteries. The battery reaction only involves a change in the valence of a vanadium ion in the electrolyte. There are none of the factors which reduce the battery service life seen in other batteries that use a solid active substance, such as loss are electro depositions of the active substance.

Furthermore, operations at normal temperatures ensure less deterioration of the battery materials due to temperature. Pumps and piping that are widely used in facilities such as chemical plants are usable as established technologies. The system configurations are such that battery output (cell section) and battery capacity (tank section) can be separated, therefore the layout of the sections can be altered according to the place of installation.

For example, the tank can be placed underground. The design can be easily modified according to the required output and capacity. The charged electrolyte is stored in separate positive and negative tanks when the battery has been charged, therefore no self-discharge occurs during prolonged stoppage nor is auxiliary power required during stoppage. Furthermore, start-up after prolonged stoppage requires only starting of the pump, thus making start-up possible in only a few minutes. The electrolyte (i.e., the active substance) is sent to the each battery cell from the same tank, therefore the charging state of each battery cell is the same, eliminating the need for special operation such as uniform charging. So that, maintenance is also easy because the electrolyte is relatively safe and the operating are at normal temperature.

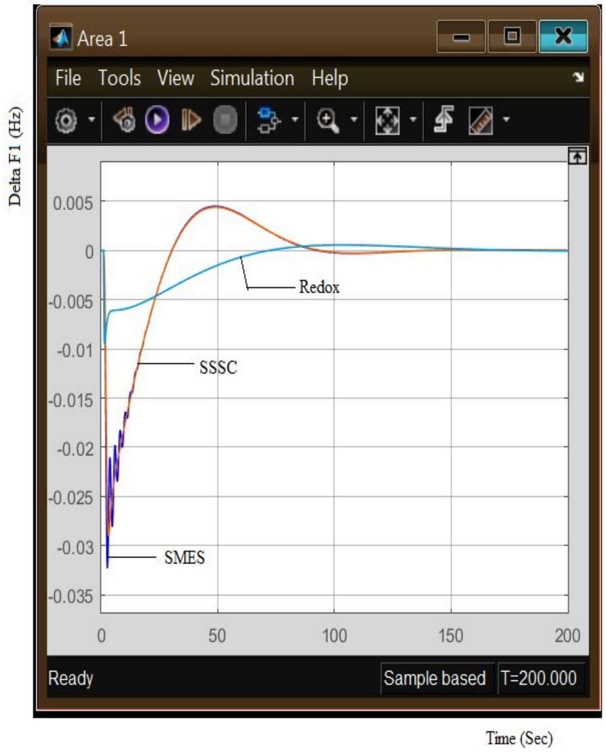

Figure 2. Tandem Single Turbine Hydrothermal Area 1

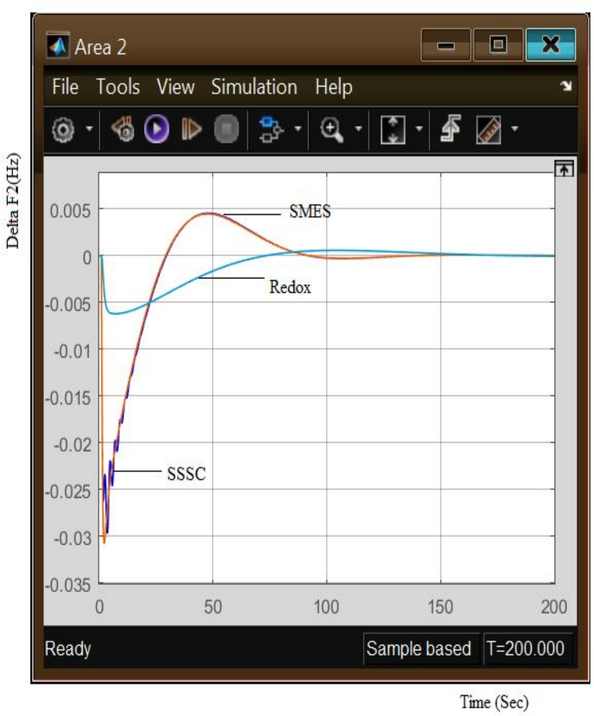

Figure 3. Tandem Single Turbine Hydrothermal Area 2

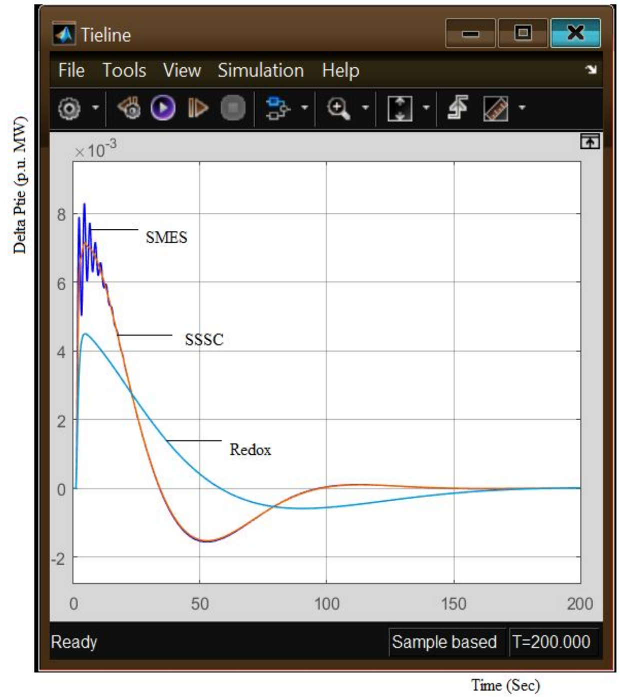

Figure 4. Tandem Single Turbine Hydrothermal Tie-line

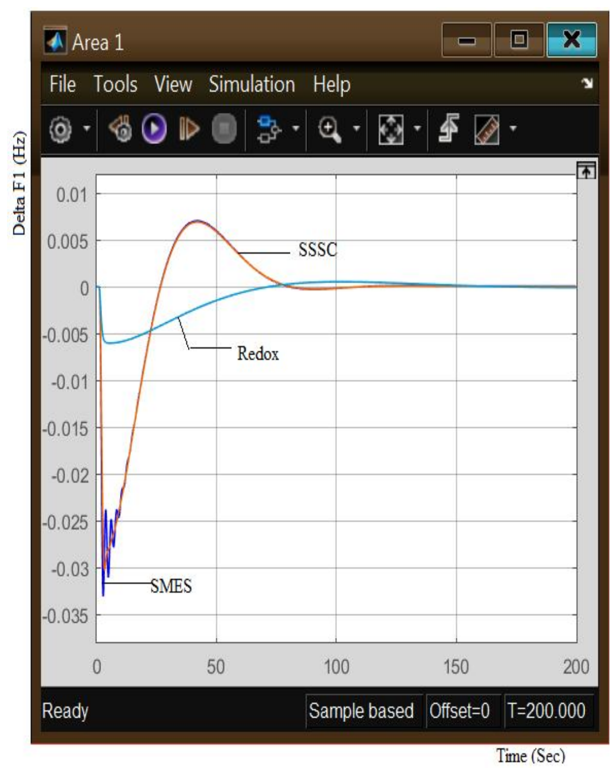

Figure 5. Cross Single Turbine Hydrothermal Area 1

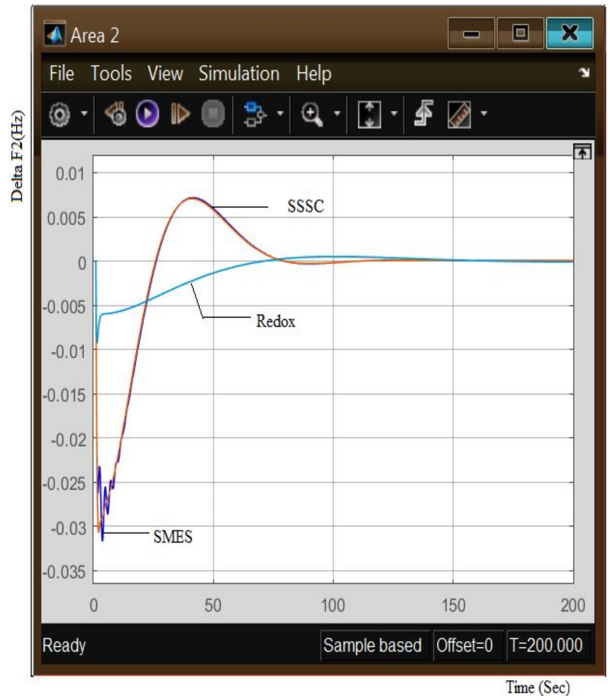

Figure 6.Cross Single Turbine Hydrothermal Area 2

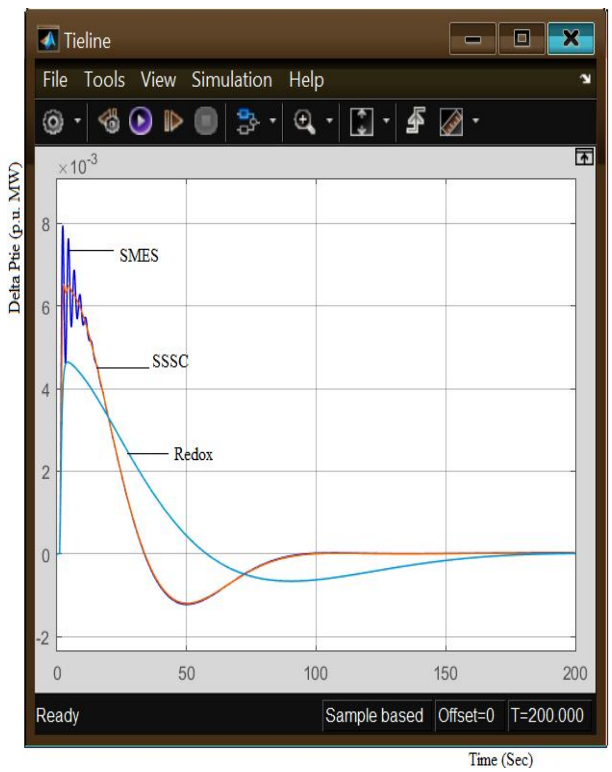

Figure 7. Cross Single Turbine Hydrothermal Tie-line

V. CONCLUSION

In this paper the responses of two area hydro-thermal power system is analysed with the presence of SMES, SSSC and Redox unit. PI controller is optimized using Ziegler Nichols method. Various types of turbines namely tandem compound and cross compound are simulated. The simulation result shows that cross compound turbine yields better performance than tandem compound turbine. The SMES is used which can effectively damp electromechanical oscillations in a power system, because they provide storage capacity in addition to the kinetic energy of the generator rotor, which can share the sudden changes in power requirement. Small rating SSSC units are connected in series with tie-line of the two area interconnected power system and response shows that they are capable of consuming the oscillations in area frequency deviations and tie line power deviations of the power system. For an overload condition for short time period because of nature of RFB the extremely faster response is obtained. The RFB unit has a reduced charging and discharging period. From this it is evidenced that RFB contributes a lot in promoting the efficiency of overall generation control through the effect of the use in load leveling and the assurance of LFC capacity after overload characteristic and quick response responsiveness. Finally the simulation result concludes that redox unit yields better performance than SMES and SSSC.

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