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Steam Turbine Control Valve Stiction Effect on Power System Stability

B. Halimi[a], Kune Y. Suh[a,b*]
[a]*Department of Energy System Engineering, Seoul National University*
599 Gwanak-Ro, Gwanak-Gu, Seoul, 151-744, Korea
[b]*PHILOSOPHIA, Inc.*
599 Gwanak-Ro, Gwanak-Gu, Seoul, 151-744, Korea
[*]*Corresponding author: kysuh@snu.ac.kr*

1. Introduction

One of the most important problems in power system dynamic stability is low frequency oscillations. This kind of oscillation has significant effects on the stability and security of the power system. In some previous papers, a fact was introduced that a steam pressure continuous fluctuation in turbine steam inlet pipeline may lead to a kind of low frequency oscillation of power systems [1, 2]. Generally, in a power generation plant, steam turbine system composes of some main components, i.e. a boiler or steam generator, stop valves, control valves and turbines that are connected by piping.

In the conventional system, the turbine system is composed with a lot of stop and control valves. The steam is provided by a boiler or steam generator. In an abnormal case, the stop valve shuts of the steal flow to the turbine. The steam flow to the turbine is regulated by controlling the control valves. The control valves are provided to regulate the flow of steam to the turbine for starting, increasing or decreasing the power, and also maintaining speed control with the turbine governor system. Unfortunately, the control valve has inherent static friction (stiction) nonlinearity characteristics [3, 4]. Industrial surveys indicated that about 20-30% of all control loops oscillate due to valve problem caused by this nonlinear characteristic.

In this paper, steam turbine control valve stiction effect on power system oscillation is presented. To analyze the stiction characteristic effect, firstly a model of control valve and its stiction characteristic are derived by using Newton's laws. A complete tandem steam prime mover, including a speed governing system, a four-stage steam turbine, and a shaft with up to for masses is adopted to analyze the performance of the steam turbine.

The governor system consists of some important parts, i.e. a proportional controller, speed relay, control valve with its stiction characteristic, and stem lift position of control valve controller. The steam turbine has four stages. The steam chest is represented by the first stage. The three other stages represent either reheaters or crossover piping. The shaft model which represents a four-mass system is coupled to the mass in a synchronous machine (generator) for a total of five masses. To analyze the oscillation in power system, an IEEE benchmark is used as reference scenario. In this scenario, a single generator is connected to infinite bus via a transmission line.

2. Steam Turbine Model

2.1 Governing System

In this paper, an electro-hydraulic speed-governing system is considered. This speed-governing type provides flexibility through a use of electronic circuit in place of mechanical component in the low power portion. A typical configuration of the speed governing system and its approximate mathematical model are shown in Figs.1 and 2, respectively.

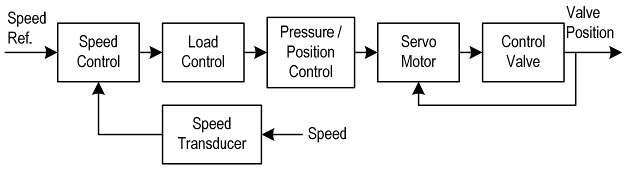

Fig. 1. A typical steam turbine electro-hydraulic speed governing system.

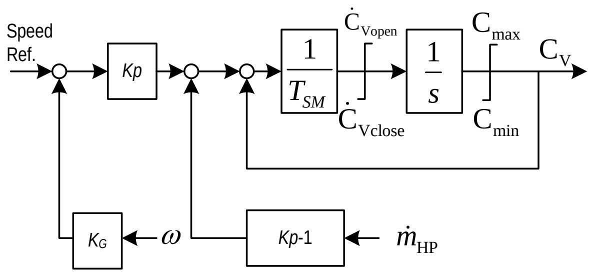

Fig. 2. Approximate mathematical model.

2.2 Steam Turbine System

For analysis, a four stage steam turbine is considered. All the stages are modeled by the first-order transfer functions. The steam chest is represented by the first stage. The three other stages represent either reheaters or crossover piping. In this model, the boiler or steam generator pressure is assumed constant at 1.0 pu. Fig. 3 shows the block diagram of the steam turbine.

3. Power System Stability Analysis

A single generator machine infinite-bus power system is considered in this analysis, as shown in Fig. 4. In this analysis it is assumed that a three-phase short circuit occurred at the high line neighbor of generator at t = 60s and the fault is cleared at 60.3s. The response of the generator active power is shown in Fig. 5. The three phases short-circuit lead to an unbalance condition between the mechanical power and the electrical power of the generator. After the clearing of fault, the operation of the governor control valves which have inherent stiction characteristics cause an oscillation on steam flow. Finally it may lead oscillation on the active power of generator as shown in Fig. 5. the active power is oscillate for 3s.

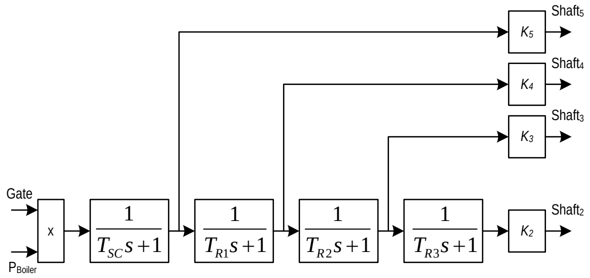

Fig. 3. Steam turbine system model.

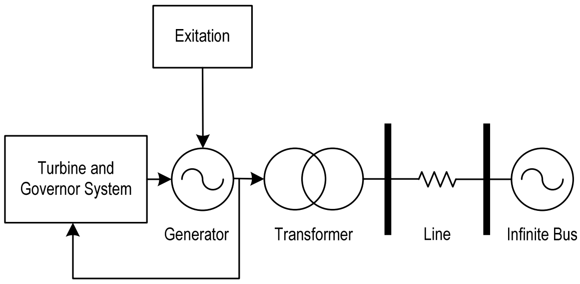

Fig. 4. Power system model.

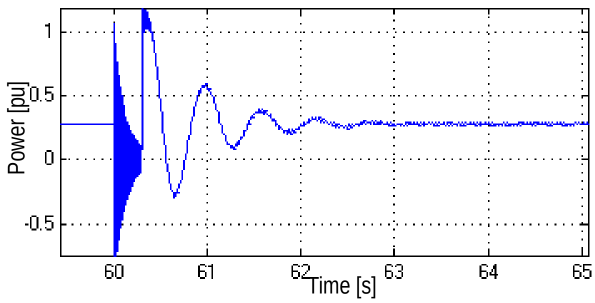

Fig. 5. Generator active power.

4. Conclusions

A steam turbine control valve stiction effect on power system oscillation was presented. To analyze the oscillation in power system, an IEEE benchmark is used as reference scenario. In this scenario, a single generator is connected to infinite bus via a transmission line. The simulation result showed that after the clearing of fault, the operation of the governor control valves which have inherent stiction characteristics cause an oscillation on steam flow. This oscillation will lead oscillation on the active power of the generator.

Acknowledgments

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REFERENCES

[1] H. Zhiyong et al., Effect of Steam Pressure Fluctuation in Turbine Steam Pipe on Stability of Power System, Third International Conference on Electric Utility and Restructuring and Power Technologies, Nanjing, China, April 6-9, 2008

[2] W. Xuanyin et al., Analysis on Oscillation in Electro-hydraulic Regulating System of Steam Turbine and Fault Diagnosis Based on PSOBP, Journal of Expert Systems with Applications, 37, pp. 3887-3892, 2010

[3] R. Clark et al., Turbine Steam Valve Diagnostic, EPRI Final Report, Palo Alto, CA, USA, 2004.

[4] B. Halimi and K. Y. Suh, Analysis of Nonlinearities Compensation for Control Valves, ICAPP'10 Conference, San Diego, CA, USA, June 13-17, 2010.