Study on Dynamic Characteristics of Rotor-bearing Model in the Hydraulic-mechanical-electric Coupled System of Hydro Generator Unit

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Long Abstract

Introduction

A hydraulic-mechanical-electric coupled model for hydroelectric shaft-bearing system was established, which contains the head conduit model of water-carriage system, the model of governor system，the model of generator's electromagnetic system and the grid. A simultaneously differential equations for coupled model, consisting of the key parameters from different systems (such as head, flow, speed and exciting current), were established and solved. Furthermore,a rotor-bearing system model is coupled to the whole system by ANSYS Parametric Design Language(APDL).On this basis, a newly method which was focused on the study of rotor system dynamic nonlinear properties during the process of operation condition's changing was introduced. In this paper, the method was applied in the rotor dynamic analysis in different start-up laws with different parameters. This analysis method could provide a reference to the stable and optimum operation of hydro generator units.

1. Methods

The operation of hydro generator is a complex process with hydraulic-mechanical-electric coupled. The shaft-bearing system is a important part of the generator,and its dynamic properties is affected by hydraulic, mechanical and electromagnetic vabration source.The single transient of one of the vabration source or coupled transient all of them were the hottest research in the field of hydropower industry.And the research of dynamic characteristics of the rotor-bearing system have been relatively mature.But there is a limitation of these studies that it lack of connection between the transient process and the spinning rotor.

In order to study the dynamic characteristic of rotor-bearing system during the transient of the operation condition's changing,which is hydraulic-mechanical-electric coupled transient,a simultaneously differential equations were established and as shown in Eq.(1).The parameters of the coupled system,such as head(H),flow(Q),rotor speed(w),excitting current(If),generator power(Pgen) and so on,could be solved by Eq.(1).

A rotor-bearing system was coupled to the model by ANSYS Parametric Design Language.The w is a key pararmeter between the two system,which is shown in Fig.(1).The dynamic properties could be studied by this coupled system.

$$
\begin{cases}
\dfrac{\partial H}{\partial t}+\dfrac{Q}{A}\dfrac{\partial H}{\partial x}+\dfrac{a^2}{Ag}\dfrac{\partial Q}{\partial x}+\dfrac{Q}{A}\sin\alpha=0 \\
\dfrac{\partial Q}{\partial t}+\dfrac{Q}{A}\dfrac{\partial Q}{\partial x}+gA\dfrac{\partial H}{\partial x}+\dfrac{fQ|Q|}{2DA}=0 \\
J\dfrac{\Omega_0^{\ 2}}{\omega_0}\dfrac{d\omega}{dt}=\left(P_{tur}-P_{gen}-P_0Dx\right)\dfrac{\omega}{\omega_0} \\
\dfrac{d\delta}{dt}=\omega-\omega_0 \\
U_q=E'_q-I_dX'_d \\
U_d=I_qX_q \\
U^2=U_q^{\ 2}+U_d^{\ 2} \\
P_{gen}=I_dU_d+I_qU_q \\
T_f\dfrac{dE'_q}{dt}=E_{fd}-E'_q-I_d(X_d-X'_d) \\
\left[b_pK_Dy''+\left(b_pK_P+1\right)y'+b_pK_Iy\right]\left(T_{yB}T_y^{\ *}y''+T_y^{\ *}y'+1\right)=K_Dx''+K_Px'+K_Ix
\end{cases}
\qquad (1)
$$

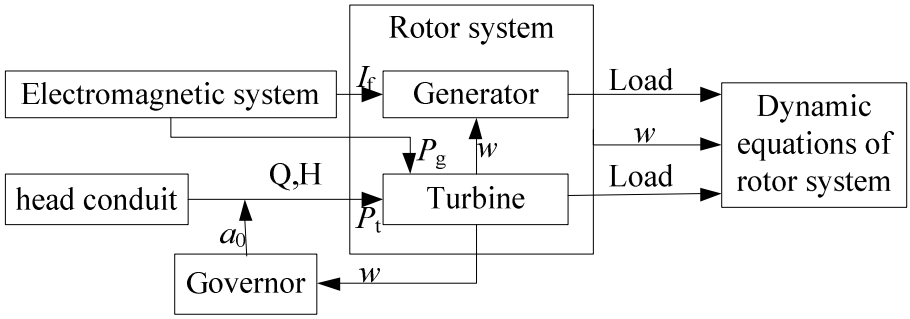

Figure.1. Sketch of coupled system

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