Torsional Vibration Analysis and Fatigue Life Estimation of Turbo-Generator Coupled Shaft Under Electrical Disturbances

A THESIS

submitted by

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for the award of the degree

of

MASTER OF SCIENCE

(by Research)

School of Engineering

INDIAN INSTITUTE OF TECHNOLOGY MANDI

Mandi, Himachal Pradesh-175005

March, 2018

DECLARATION

*This is to certify that the thesis titled "***Torsional Vibration Analysis of Turbo-generator shaft due to electrical disturbances and Fatigue life Estimation***" submitted by me, to the Indian Institute of Technology Mandi for the award of the degree of* ***Master of Science (by research)****, is a bona fide record of the research work carried out by me in the School of Engineering, Indian Institute of Technology Mandi, under the supervision of Dr. Rajeev Kumar and Prof. S. C. Jain. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.*

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THESIS CERTIFICATE

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ABSTRACT

In a power plant, electrical disturbances induce electromagnetic torque in the generator. This electromagnetic torque generates torsional vibration in whole turbo-generator shaft system. Sometimes these vibrations cross the fatigue limit causing partial or complete failure of a turbo-generator shaft that finally leads to an unexpected shutdown of the power plant.

In this thesis, investigation of shaft damage due to torsional vibrations initiated by three phase, two phase, single phase short circuit and synchronization fault on the power system has been carried out for the unloaded and loaded generator. A mathematical model of a generator has been developed to predict the electromagnetic torque under various electrical disturbances. Developed model has been simulated using Adams-Predictor corrector scheme, the startup being tackled by the fourth order Runge-Kutta method. Predicted electromagnetic torque has been applied to the turbo-generator shaft. Turbo-generator shaft has been modelled using the finite element method. Based on the shape of individual section two nodded solid cylinder, hollow cylinder or tapered, finite elements have been considered. Torsional vibration response under electromagnetic torque has been predicted using Duhamel integral. The Min-max algorithm has been used to convert the number of cycles of corresponding amplitude of stress. Finally, shaft damage has been calculated using Palmgen-Minor rule.

Numerical results predict that stator current, field current, angular velocity and electromagnetic torque dominate under three phase short circuit fault over two phase short circuit and single phase short circuit fault. Torsional vibrations induced during three phase short circuit are higher than two phase short circuit and single phase short circuit. Further, maximum value torsional moment not only depends on the location at shaft but also on the duration of the short circuit. Fatigue damage during short circuit is different at different locations of the rotor system and highest for three phase short circuit.

Keywords: Generator short circuit, Three phase short circuit, Two phase short circuit, Single phase short circuit, Torsional moment, Electromagnetic torque, Finite element method, Duhamel-Integral, Vibration, Fatigue.

ACKNOWLEDGEMENTS

I would like to offer my sincerest gratitude to my thesis advisors, **Dr. Rajeev Kumar** and **Prof. S. C. Jain**, for giving me detailed guidance and innovative inputs to my research project and for guidance and encouragements throughout this work.

I am extremely thankful to **Dr. Rajeev Kumar** for his support and the direction that he has provided for this work from the beginning.

Besides my advisors, I would like to thank my Annual progress committee members **Dr. V. S. Chauhan**, **Dr. M. Talha**, **Dr. Atul Dhar** and **Dr. Manoj Thakur** for their kind coordination and valuable time. There are also a group of people in my school who provided generous help in the course of my M. S. program. I would like to give special thanks to Tarun Kumar, Anuruddh Kumar, Saurav Sharma, Sumeet Sharma and Satish Kumar for their assistance. I am also thankful to my friends Sarthak Nag, Priybrat Sharma, Neha Thakur, Subrata Mondal, Gaurav Sharma, Moumita Ganguly and Abhishek Bhide for their support in various issues.

I am ever grateful to my parents, my brother Prasad and sister Pooja for their constant love and confidence in me.

Finally, Thanks to almighty God.

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