CONCLUSIONS AND POSSIBILITY DESIGNED FOR FUTURE INFORMATION

The purpose of the current analysis is to promote a robust method for predicting and quantifying the crack location and its severities in dynamic structures subjected to complex loading using dynamic responses. To accomplish the desired purpose, the whole attempt has been executed to estimate the impact of transverse cracks on the modal parameters of the dynamic structures containing shafts. Throughout the investigation, theoretical method, finite element approach (ANSYS) and experimental approach have been used to evaluate the dynamic responses of the shaft with different end condition. The calculated fundamental natural frequencies along with their mode shapes for first three modes of vibration are identified as input parameters for crack quantification. These parameters have been utilized to design the AI techniques controllers like genetic algorithm, artificial neural network (ANN), artificial neuro-fuzzy inference system (ANFIS) and hybrid GA-MANFIS techniques for predicting the crack locations and crack depths in the shaft. The investigations and reviews of results are made in separate chapters of this thesis. The outcomes extracted are described below.

11.1 Groundwork

It is notified that the cracks commenced in dynamic systems influence local compliance. The crack depths and locations alter the local compliance of structural elements. Due to the variation of flexibility, the natural frequencies and amplitude of vibrations change. In the early analysis, researchers have considered the influence of crack on frequency responses in damaged structures. However, in the present investigation, the attempt has been initiated to outline a hybrid AI technique to predict the crack severities in the dynamic structures such as shaft by using the fundamental natural frequencies with their mode shapes. In the theoretical analysis, a model of the shaft has been produced and applying stress intensity factors (SIF) as well as strain energy release rate(SERR), the differences in vibration signatures due to the presence of multi-cracks are estimated. In a similar way, the variation in natural frequencies and mode shapes are computed applying finite element analysis (ANSYS) and experimental approach at different crack locations and crack depths. Various AI procedures have been formulated for identifying multiple
cracks in shaft using the genetic algorithm (GA), artificial neural network (FFBP), artificial neuro-fuzzy inference system (ANFIS), and hybrid techniques such as GA- MANFIS.

11.2 Judgments

The judgments are based on the results obtained from different methodologies described below:

- Theoretical model and finite element (ANSYS) model have been performed to generate the vibration signatures (mode shapes and frequencies).

- The mode shapes and fundamental natural frequencies of the cracked shafts are strongly influenced by the presence multiple cracks as noted from theoretical analysis. The crack locations have produced a larger effect on the dynamic response of shaft. The rate of change in natural frequency reduces sharply while the crack location is towards the rigid end. As the crack size increases (from mild crack to high crack), there is a bigger drop in natural frequencies for the cantilever, fixed-fixed and simply supported shaft. The deviations of the mode shapes are found to be more for high crack depth.

- Experimental analysis of the cracked and uncracked cantilever, fixed-fixed and simply supported shaft with the various forms of crack depths (mild crack, medium crack and high crack) have been implemented along with crack locations to examine the modal parameters. The collected results from the theoretical and ANSYS model are in close agreements with experimental results.

- The deviation in vibration signatures due to the presence of crack and its severity in cantilever, fixed-fixed and simply supported shaft will be utilized to design the controller of Genetic algorithm for prediction and quantification of crack locations and its depths. The model is trained up with ten inputs parameters obtained from the theoretical and finite element and validated by the results collected from the experimental analysis. Finally, four outputs parameters such as two crack locations and two depths are obtained. The proposed evolutionary algorithm provides results in closeness to the test results. From the report of its performance, it is said that the GA model can be applied as a sound multiple crack identification device in the technical environment.
An artificial neural network pattern with ten inputs has been designed to train and test the population data obtained from analytical and FEA analysis. The test results are fed to know the effectiveness of model and four outputs are obtained (crack locations and crack depths). The results obtained by the neural network are proximate to the test results. Learning through the evidence, it is observed artificial neural network model can be usefully applied for detection of the crack in dynamic structures with cracked shaft.

From the results (crack depths and locations) of the GA and artificial neural network model, it is apparent that the results from the artificial neural network are more closer to the test results as compared to the improved GA models. An adaptive neuro-fuzzy inference system (ANFIS) with four layers model has been selected to represent the fault detection technique for the shaft structure. The ANFIS model has been designed with Gaussian and trapezoidal membership functions.

From the summary of the results, it is observed that the outcomes of ANFIS model are more accurate in comparison to GA and ANN model. Therefore, the ANFIS method planned for multiple crack detection can be a better model than that of others AI technique for condition monitoring for faulty dynamic structures.

Hybrid GA-Multiple adaptive neuro-fuzzy inference methods have been implemented to decrease error and to locate multiple transverse cracks in the dynamic structure. Based on the observations of the predicted results from the GA-MANFIS model, it is declared that the hybrid GA-MANFIS method can recognize the crack parameters including depth and location with almost accuracy in comparison to GA, ANN and ANFIS model. The results are in closer proximity with the experimental results. Consequently, the improved hybrid fault diagnostic technique is intelligent of recognizing cracks in a dynamic system and can be applied for online structural monitoring.

Subsequently, the GA-MANFIS design is decided to be a quite appropriate artificial intelligent method to recognize multiple cracks in intelligent dynamic vibrating structures with the smallest error.

The improved fault diagnostic intelligent method can be used for online condition monitoring of shafts of a turbine, structures of marine, supported beams, any
structure containing shaft, wings of the aeroplane and all vibrating structures in engineering applications.

11.3 Scope for Future Study

The hybrid artificial intelligent methods may be improved to predict cracks in complicated manufacturing structures. Thus, there is an opportunity for broad range of applications of AI method for condition monitoring of susceptible members. Few of the application are given below:

- The use of AI techniques may be used for detecting multiple cracks presents in alloy components and composite material.

- Further, appropriate hybrid methods may be developed and implemented for detecting the multi-cracks in complex vibrating parts like as railway tracks, oilrigs, turbine shafts etc.

- The scope for future study may be extended to apply fault diagnosis technique to the complete dynamic structure instead of its part.

- The hybrid AI technique may be monitored with the signal system for condition monitoring of the dynamic structure.

The artificial intelligence techniques may be integrated with dynamic systems to perform online condition monitoring.