REVIEW OF NUMERICAL SOLUTION TO THE DETECTION OF CRACK IN STRUCTURE BY USING FUZZY LOGIC

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ABSTRACT

This paper is review of the solution to the crack detection in structure using Fuzzy logic. Crack is the discontinuation in a body. The presence of crack leads to changes in some of the lower natural frequencies. The concept of vibration can be applied to identify the crack location.Since most human activities involve vibration in one form or other. The vibrations having certain amplitude and frequency may be reliable for human being. Modern non-destructive techniques to detect the cracks are time consuming. Fuzzy logic technique is the alternative for non-destructive Testing techniques. This technique gives approximate solution for the crack detection in structure.

Keywords: Crack Detection, Fuzzy Logic, Nondestructive Method, Review Paper.

I INTRODUCTION

For crack detection of structure, vibration based methods make a good approach. Vibration based methods use the fact that due to the presence of the crack, there is a change in the flexibility which affects the natural frequency of the structural element.The rule-based fuzzy logic provides a scientific formalism for reasoning and decision making with uncertain and imprecise information.This proposes online crack detection methodology embedded with a new intelligent Fuzzy Interface System. In this approach a fuzzy logic controller is designed and implemented for identifying relative crack depth and location. The designed fuzzy controller has three inputs and two outputs. The inputs for fuzzy controller are three modes of natural frequencies and two outputs are relative crack depth and relative crack location.Vibration-based methods have been proved as a fast and inexpensive means for crack identification. A crack in a structure induces a local flexibility which affects the dynamic behaviour of the whole structure to a considerable degree. It results in reduction of natural frequencies and changes in mode shapes. An analysis of these changes makes it possible to determine the position and depth of cracks. Most of the researches used in their studies are open crack models, that is, they assume that a crack remains always open during vibration. The assumption of an open crack leads to a constant shift of natural frequencies of vibration.

II LITERATURE REVIEW

Research of different researchers on crack detection in structure is as follows.

- Amiya Kumar Dash represents the multi crack detection of structure using fuzzy Gaussian technique. He derived from thevibration parameters numerical methods of the cracked cantilever beam to set several fuzzy rules for designing the fuzzy controller used to predict thecrack location and depth.
- Dayal R. Parhi and Sasanka Choudhury a cantilever beam with a single crack has been taken into consideration. Finite element method is used to find out the natural frequencies of the faulty cantilever beam. A fuzzy controller has been designed using trapezoidal, Gaussian as well as triangular membership function to find out the crack depth and crack location.
- Meysam Siyah Mansoory attempt to evaluate the performance of the SUSAN edged Detector for noisy images based on fuzzy thresholding. Experimental results have demonstrated that the SUSAN edge Detector works quite well for digital images noisy with Gaussian noise Because the SUSAN algorithm uses no derivative too the proposed algorithm is less sensitive to noise than other edge detectors. Meanwhile this algorithm in comparison with other method had processing time less than other in this field.
- N. V. NarasimhaRao Rao proves the vibration analysis of crack cantilever beam with open transverse crack. A fuzzy logic interface system is used to analyze the crack in cantilever beam. A series of fuzzy rules are used finally for prediction of crack depth and crack location.
- D.K. Agarwalla concludes crack detection and localization is the main topic of discussion for various researchers across the globe. It is concluded that results obtained from experiment have a very good agreement with the results obtained from FEM and the structure vibrates with more frequency in the presence of a crack away from the fixed end.
- R. Tiwari and M. Karthikey developed identification procedure for the detection, localization, and size of a crack in a beam based on forced response measurements. They used circular beam supported by rolling bearings at both ends for this experiment.
- S Lalonde J Lanteigne, F Leonard, and Y Turcotte studied cracks that occurred in metal beams obtained under controlled fatigue-crack propagation.
- An analytical and experimental approach by H. Nahvi and M. Jabbari et al. to the crack detection in cantilever beams by vibration analysis. Sensibility analysis of the inverse problem of the crack parameters (location and depth) determined by M. B. Rosales, C P Filipich and F S Buezas et al. An efficient numerical technique is necessary to obtain significant results.

III THEROTICAL FORMULATIONS

For crack depth and location,the terms RCD and RCL are considered and calculated by the formula,

$$RCL = \frac{\text{distance of crack grom fixed end}}{\text{length of the beam}} \qquad (1)$$

$$\text{RCD} = \frac{\text{depth of the crack}}{\text{depth of the beam}} \quad (2)$$

It is assumed that the natural frequency changes due to the change in moment of inertia only. The beam made up of structural steel material by extrusion process. The Young's modulus for the beam material of length 700 mm is 210×10^9 N/m^2.The beam models no. 1 to 5 is of rectangular cross section while beam model from 6 to 10 are of square cross section.

IV FUZZY LOGIC TECHNIQUE

Fuzzy logic system is inspired by the remarkable human capability to operate on and reason with perception-based information. The rule-based fuzzy logic provides a scientific formalism for reasoning and decision making with uncertain and imprecise information. A general model of a fuzzy inference system (FIS) is shown in Figure 2. The fuzzifier maps input numbers into corresponding fuzzy memberships. This is required in order to activate rules that are in terms of linguistic variables. The fuzzifier takes input values and determines the degree to which they belong to each of the fuzzy sets via membership functions. The inference engine definesmapping from input fuzzy sets into output fuzzy sets.

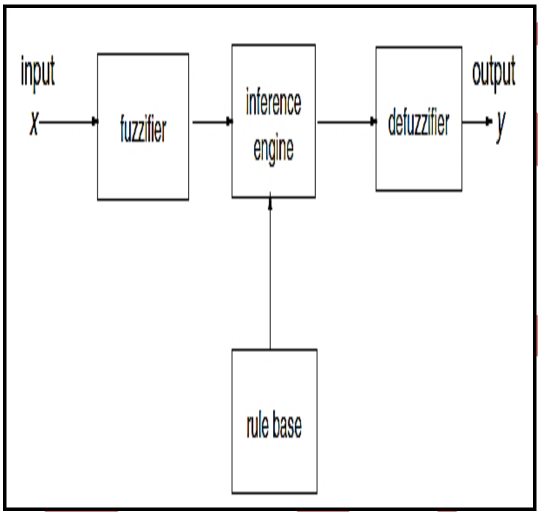

Fig:1 Diagram of a Fuzzy Interface System

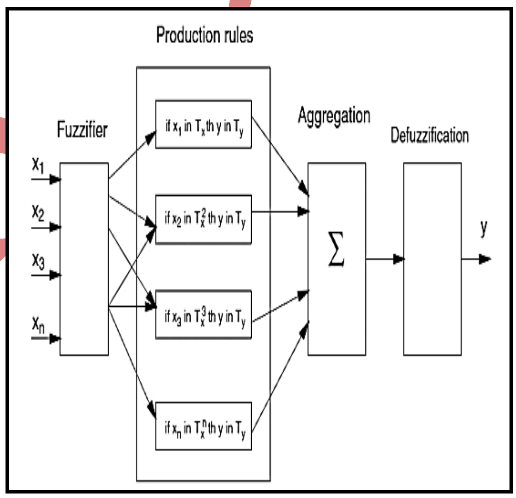

Fig: 2 Block Diagram of Fuzzy Interface System

For a given input, more than one rule may fire. Also, in an FIS, multiple regions are combined in the output space to produce a composite region. A general schematic of an FIS is shown in Figure1.

Fuzzy rules are fired in parallel, which is one of the important aspects of an FIS. In an FIS, the order in which rules are fired does not affect the output. The defuzzifier maps output fuzzy sets into a crisp number. Given a fuzzy set that encompasses a range of output values, the defuzzifier returns one number, thereby moving from a fuzzy set to a crisp number. The result of fuzzy logic or outputs from fuzzy logic has been tabulated in Table 1. Here input for fuzzy logic is different modes of natural frequency and output will be relative crack depth and relative crack location. The natural frequency are obtained from finite element formulation are taken for developing fuzzy model.

Beam no.	Fuzzy Logic	
	RCD	RCL
1	0.052	0.065
2	0.191	0.239
3	0.34	0.25
4	0.2	0.433
5	0.212	0.424
6	0.16	0.25
7	0.167	0.25
8	0.3388	0.25
9	0.1608	0.348
10	0.3416	0.427

Table 1 Fuzzy Logic calculation of Relative Crack Depth & Relative Crack Location.

V CONCLUSION

We can draw following conclusions

Changes in natural frequency observed at the area of crack location. When the crack depth is constant and crack location increases from the cantilever end natural frequency decreases. As square cross section beam have same transverse and longitudinal frequency, it is better to use rectangular cross section beams since they have larger transverse frequency than longitudinal. When the crack depth increases and the crack location is constant the natural frequency of the beam decreases.

Crack depth and crack location of a beam can be predicted by fuzzy controller is within nanoseconds. Hence it saves considerable amount of computation time. By Comparing the Fuzzy results with the theoretical results it is observed that the developed Fuzzy Controller can predict the relative crack depth and relative crack location in a very accurate manner. Here an approach can be suggested which is based on the combination of both ANSYS and Fuzzy, in which natural frequency obtained in ANSYS can be used as input for fuzzy controller for determination of accurate value of crack depth and crack location

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