INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Debaleena Chakraborty

Roll Number : 11610307

Programme of Study : Ph.D.

Thesis Title: "Strain Gage Based Determination of Stress Intensity Factors in Cracked Orthotropic Materials"

Name of Thesis Supervisor(s) : Dr. D. Chakraborty and Dr. K.S.R.K Murthy

Thesis Submitted to the Department/ Center : Mechanical Engineering Department

Date of completion of Thesis Viva-Voce Exam : 12.05.2017

Key words for description of Thesis Work : Strain Gage, Orthotropic, Stress Intensity Factors, Optimal locations

SHORT ABSTRACT

In the last few decades considerable attentions have been paid by researchers in extending the concepts of LEFM pertaining to homogenous, isotropic materials to orthotropic composite materials. Stress intensity factor (SIF) being an important parameter in LEFM, accurate determination of SIF of cracked orthotropic materials have been an important area of research. Existence of cracks and notches in laminated composites warrants that SIFs are known to assess whether such cracks grow further during service leading to interlaminar or intralaminar defects in orthotropic laminates. Strain gage technique being one of the simplest experimental method for determination of SIFs could not be successfully used in the case of cracked orthotropic materials. This is due to the fact that unlike isotropic materials, proper theoretical formulations supporting such experimental determination were not reported for orthotropic materials. Even though there were one/two attempts but there were no theoretical guidelines suggesting the number of strain gages and more importantly their locations ensuring accurate determination of SIFs. The present thesis works towards filling these gaps with an objective to facilitate strain gage based accurate determination of SIFs of cracked orthotropic materials. Starting with Westergaard's stress function, and using a three parameter strain series, a single strain gage technique has been developed for accurate determination of K_I in cracked orthotropic materials. A method has also been developed which makes it possible to determine optimal location of the strain gage ensuring accurate estimation of K_I before conducting the experiment. Similarly, using appropriate stress functions and three parameter strain series, theoretical formulations have been developed for a mixed mode problem making it possible to determine K_I and K_{II} accurately by placing four strain gages in the locations and orientations prescribed in the present work. A method has

been proposed to determine the optimal locations of strain gages before actual experiments which ensures accurate determination of K_I and K_{II} from the strain gage based experiments. Finally, edge cracked $[90_2/0]_{10S}$ carbon-epoxy laminates have been prepared and the experimental set-up for conducting strain gage based determination of K_I has been designed. Large number of experiments have been performed on laminate specimens of different crack sizes and the experiments are also repeated number of times to ensure repeatability. Results from both numerical simulations and experiments conducted led to some important observations and conclusions. Proposed theoretical formulations, numerical results and experiments show that for cracked orthotropic materials, it is possible to determine K_I using only one strain gage and K_I and K_{II} using four strain gages provided the strain gages are placed within the suggested optimal locations. These optimal locations of strain gages depend upon the crack configuration (size, inclination). More importantly, results show that the procedure put forward for determination of optimal strain gage locations is robust. Experimental and numerical results also show that while highly accurate values of SIFs could be obtained by placing the strain gages within optimal locations, a very high error ($\sim$ 49 %) is incurred if the strain gages are placed at non-optimal locations thus reinforcing the existence and importance of optimal strain gage locations in experimental determination of SIFs in orthotropic materials.