The 50th JUACEP Seminar

第 50 回 名古屋大学日米加協働教育プログラムセミナー

13:30-15:00 Wednesday, February 27, 2019

Lecture Room 221 (2F, Eng.Bldg. II)

BIRDSTRIKE : WHAT IS IT & WHAT DOES IT TO AIRCRAFT?

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ABSTRACT

The extreme operating conditions present inside a turbofan engine, foreign object damage and birdstrike increase the likelihood of catastrophic failure of the blades, referred to as blade-out. Blade-out can involve the failure of compressor, turbine, or fan blades and can cause severe damage to the engine, wing, or fuselage and result in the loss of lives. The failure of fan blades, referred to as fan blade-out (FBO) is the most severe, since the fan blades are the largest blades in the engine and have the most kinetic energy. Due to the potential severity of a FBO event, all engine manufacturers include a containment structure (ring) which surrounds the rotating sections of the engine. This structure is designed to absorb the energy of a released blade and to contain the blade fragments so that they do not pierce fuel tanks, hydraulic control lines, and/or the fuselage. Unfortunately, current accidents show that containment structure designs are inadequate and better designs are needed.

Accordingly, this study is concerned with the design and analysis of a novel containment ring for turbofan engines using dynamic nonlinear finite element (FE) simulations and a blade-out testing apparatus. Three aspects of the work were accordingly examined. The first is concerned with the response of multilayered targets to normal and oblique impacts by a blade-like projectile. This enabled the selection of the most appropriate material combination for the containment ring. The second is concerned with the response of the selected target to blade-out impacts with partially and fully bladed fan disk. The third is concerned with the design and instrumentation of a novel test rig to calibrate the finite element simulations and examine the true response of blade-out in turbofan engines. The predictions of the finite element method reveal that Kevlar is suitable for use in containment rings. It further shows that the optimal multilayered target is the one where the exposed surface is made of aluminum foam and backing is made of Kevlar fabric. This is also confirmed in the containment of blade-out with a single trailing blade and fully bladed fan disk.

Keywords: *Birdstrike, Turbofan, FBO, Containment ring, Modeling, Novel design*

Biographical sketch

Prof. Shaker Meguid is an internationally renowned scholar with significant contributions in computational and experimental mechanics at varied length scales. He is the Founding Editor-in-Chief of Int. J. of Mechanics and Materials in Design, former Technical Associate Editor of ASME J. of Engineering Materials and Technology (for two consecutive terms), former Associate Editor of IMechE Journal of Mechanical Process Engineering, Guest Editor to a number of Journals. He is also the Founding Head of the Aerospace Engineering Division of Nanyang Technological University, Singapore. He is an Engineering Consultant to the United Nations, a lifetime senior member of AIAA, member of the American Academy of Mechanics, Professional Engineer in the Province of Ontario (PEng), Chartered Engineer in Great Britain (CEng), Fellow of ASME, Fellow of IMechE and Fellow of the Engineering Institute of Canada. He works closely with the aerospace and automotive industries and is regularly approached by members of the media for clarification of engineering issues and accidents. Prof. Meguid and his research team won numerous awards, with the most recent honor being the nomination by his department for the gold medal by the Governor General of Canada, holder of the Robert Hooke Award bestowed by the European Society for Experimental Mechanics, Engineering Award-Research and Development by the Professional Engineers of Ontario for his significant contribution to research and development in Canada.