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NSMS를 이용한 터빈 블레이드 진동 분석에 관한 연구

Vibration Analysis of Turbine Blades Using Non-intrusive Stress Measurement System

정규강 · 강석철 · 팽기석* · 박노길** · 김남웅***

Kyu-Kang Joung, Suk-Chul Kang, Ki-Seok Paeng, No-Gill Park and Nam-Eung Kim

Key Words : Non-intrusive Stress Measurement System(비접촉 응력 측정 시스템), High Cycle Fatigue(고주기피로), Blade Vibration(블레이드 진동)

ABSTRACT

Measurement of stress on a turbomachinery blade or disk can be accomplished by placing a strain gage(s) on a component, running thin wires onto the part, up the rotating shaft, and out to a device called a slip ring or telemetry unit. This technique has significant problems and is being replaced by systems that measure blade vibration using non-intrusive sensors mounted in the engine case. The relationship between blade displacement and blade stress depends on the geometry of the blade tip, the sensor location and the mode shape and when coupled with a finite element model of the blade, the tip deflection can be related to the maximum vibratory stress. Non-Intrusive Stress Measurement Systems (NSMS) can measure blade deflection by detecting the time-of-arrival of every blade on every revolution..

Samsung Techwin and Hood Technology developed a Non-Intrusive Stress Measurement System to measure coupled vibration modes on a high pressure turbine. These systems can report the actual stresses seen on the blades; detect synchronous resonances that are the source of High Cycle Fatigue (HCF) in blades; measure individual blade mis-tuning and even help separate complicated, coupled resonances in bladed disks. Tests were successfully performed at high temperature and measured both tip timing and tip clearance of all blades. A special optical Skewed Dual Light Probe was used that employs two channels (fiber bundles) in a single sensor to measure both tip timing and tip clearance simultaneously. The sensor was also modified to have a very tight bending radius of 5mm. A finite element analysis was performed prior to the test to determine the potential vibration modes, and data was taken during RPM sweeps using predominately three sensors on the same chord-wise position. Both integral and non-integral aggregate responses were measured, along with tip-clearances synchronous vibration data. Single Degree of Freedom (SDOF) and Circumferential Fourier Fit analyses were performed on the data, and two dominant response orders were identified. Non-Intrusive Stress Measurement Systems(NSMS) was used successfully in measuring tip deflection and tip clearance, and was consistent over many runs. The SDOF curve fit and Circumferential Fourier fit were used to identify resonance amplitudes, resonance RPM and damping for all blades. The results of the two data-reduction methods matched well. Because tip deflection for every blade can be obtained with NSMS system, it might be possible to reduce the fatigue margin relative to the fatigue margin based upon strain gage data from a few blades.

* 삼성테크윈 파워시스템연구소
E-mail : kk.joung@samsung.com
Tel : (055)260-2933, Fax : (055) 260-2887

** 정회원, 부산대학교 기계공학부

*** Hood Technology