ACTIVE CONTROL OF FAN NOISE BY VANE ACTUATORS pdf

1: New technology reduces fan noise without the cost of silencers | INVC

Vane actuators offer a method of applying active noise control at the source of the disturbance [3]. As both the unsteady forces of the fan wake passing over the vane.

Seven radials combined inlet and exhaust were present at this condition. Several different error-sensing strategies were implemented. Integration of the error-sensors with passive treatment was investigated. The effect of incorporating passive treatment was investigated as well as reducing the actuator count. These simplified systems were compared to a fully ANC specified system. Modal data acquired using the Rotating Rake are presented for a range of corrected fan rpm. Simplified control has been demonstrated to be possible but requires a well-known and dominant mode signature. The documented results herein are part III of a three-part series of reports with the same base title. Part I and II document the control system and error-sensing design and implementation. A component of EPNL is fan tone noise caused by rotor-stator interaction and duct modal propagation. The number of arrays required is related to the highest radial mode in the m-order to be controlled. These systems have been shown to successfully reduce multiple radial modes, but concern has been expressed about the large number of components required. The systems implemented used fewer than the ideal maximum, but not substantially so. An earlier effort reduce the number of components 7 was demonstrated on the ANCF. Reductions in selected farfield sectors were attempted using a wave-number sensing technique or farfield error-sensors and a single circumferential array source in a three radial environment. Reductions were modest, but the techniques were validated. This report should be considered Part III of a whole; Part f and Part If provide more detail of the analysis and development of the systems. For research, the dome serves provides an ancchoic environment down to Hz for acoustic measurement of aero-propulsion components. The ANCF is a ducted fan used to test noise reduction concepts fig. A bladed rotor in combination with a variable stator vane-count and axial -spacing produces the desired rotor-stator interaction modal content. No internal support struts are required since the center body and duct walls are fixed to the support structure Internal struts could result in additional interaction acoustic duct modes, resulting in a more complicated mode structure. Inflow and turbulence distortions that would introduce asymmetric loading of the blades are minimized by an inflow control device ICD at the inlet. The corrected fan speed range was from to crpm, in crpm increments. Three radials were cut-on in the inlet below crpm; above crpm there were four radials. Two radials were present in the exhaust below crpm; above crpm there were three radials. The design test condition of seven cut-on radials occurred at and crpm. The corresponding 2BPF was to Hz. In-Duct Measurements Acoustic mode in-duct levels were measured using the NASA rotating rake modal measurement system that independently measured the effect of the ANC system on each propagating mode. Time domain averaging is used to reduce noise unsynchronized to fan rotation and narrow band spectra are used to extract the magnitude and phase of each m-order component for each microphone. Different m-orders appear as distinct spectral lines frequency shifted due to Doppler effects. A set of Bessel functions appropriate to the m-order is then fitted to the data in a least square sense to obtain the radial mode content. There are two rake microphone arrays for the ANCF, a seven-microphone array for the inlet and a six-microphone array for the exhaust only one rake is installed at a time. A gear mechanism rotates the rakes at one-hundredth the rate of the fan. The microphone signals are sampled synchronously with the rotation of the fan and hence synchronously with the interaction spinning acoustic modes generated by the fan. The result of the rake processing is a set of spinning mode amplitudes and phases at the rake location. It is assumed that reflections from duct terminations are negligible and that the spinning mode amplitudes represent the amplitudes of modes propagating from fan to the duct termination, and then radiating to the far field. A NC Sy ste m The program objective was to simplify the control strategy. For this program, simplification was defined as reduction of the number of components used by the ANC system compared to previous ANC concepts. All variations in sensing arrays used the full set of actuators. A separate configuration investigated the effect of reducing the number of actuators used. The effect of incorporating passive treatment in the ANC system was also tested. These actuators were driven with current controlled amplifiers, two actuators per amplifier. The actuators were driven in seven independent 30 element circumferential arrays. Fourteen element circumferential arrays of microphones in the ANCF were used for the error inputs. Subsets were chosen to implement the simplification strategies from these global sets. Figure 2 shows a schematic of the control system hardware mounted on the ANCF. Test Results The primary data reported herein Part I is modal breakdown as measured by the rotating rake. The results are limited to target mode PWL reductions obtained because the spillover generated by the actuators contaminated the over-all PWL measurements. The unique measurement ability of the rotating rake allowed the effects of the ANC on the target acoustic mode to separated from the 2 American Institute of Aeronautics and Astronautics contamination. Farfield SPL directivity results are also presented for configurations that target limited control to sectors in the farfield. Arrays Control of spinning modes using in-duct circumferential arrays was selected as the baseline control case. The standard technique of choosing the number of microphones in each array based on the maximum m-order to be detected was used. However, experience with the ANCF has shown that for this operating condition ten microphones per array are adequate to prevent any significant problems with aliasing. The number of circumferential arrays was determined based on the highest radial cut-on at the target circumferential mode. This requirement dictated four circumferential arrays in the inlet, and three in the exhaust. Thus, 70 error-sensing microphones were required to control the seven radials. The hard-wall configuration treatment was taped over with a fan speed of crpm was selected to investigate the optimum sensor configuration for the inlet. Various selections of four arrays of the eight available were chosen to control the four radial modes in the inlet. Figure 3a shows the reduction achieved using selected inlet arrays. Refer back to figure 2 to determine the axial location of the arrays. For a given configuration, a variation of several dB in noise reduction was observed for a given configuration due to a variety of causes, such as how recently the plant transfer functions had been measured, changes in various filter and gain settings, etc. The performance was not sUongly dependent on the error sensor configuration, a result consistent with the simulation results in reference 8. Other configurations provided nominally 10 dB of reduction. The axial extent of these configurations is These configurations were tested over the range of to crpm and the results are compared on figure 3b. At crpm, several control attempts were made for each configuration and the range of results is shown to overlap suggesting nearly identical results over the entire crpm range. A significant result is that modest to significant reduction 1 to 13 dB is achieved in the exhaust when controlling only the inlet. Previous ANC experiments have often showed an increase in the exhaust when controlling the inlet. Neither was this result predicted by the simulations described in Part I. In fact, those simulations predicted a slight increase in exhaust duct radiation at RPM. This result is significant because it indicates that the control system can focus on just the inlet if most of the sound radiation comes from there and not fear that sound radiation from the exhaust will increase but might in fact decrease. The beneficial result seen here may be due to the close coupling of the actuators to the stator source. The results of the exhaust array selection are shown in figure 4a. The data shown are the reductions obtained in the exhaust, at crpm fan speed, with three or more of the six error sensor arrays in the exhaust selected. As indicated by the simulations, there is not a large difference in performance for different sensor arrays. The three inner arrays, or all six arrays which is over specified , provide somewhat better performance. Figure 4b shows these cases for the tested fan speed range. Up to ten dB reduction occurs, with using three resulting in the best reduction. Figure 4c shows the inlet levels obtained when controlling in the exhaust. Again, the veiy interesting result is that up to 7 dB of reduction is obtained in the inlet when the exhaust is controlled. This is particularly significant because the uncontrolled fan inlet levels are 6 to 15 dB higher than the exhaust. Simultaneous inlet and exhaust dual control was also demonstrated. Figure 5a shows the inlet levels obtained with dual control; figure 5b that obtained for the exhaust. It is significant that the reduction obtained with dual control is less than that with uni-directional control, regardless of which duct is being controlled. That is, controlling solely in the inlet which is under-specified results in better reductions in the inlet and exhaust than that obtained by dual control which is fully specified. The reduction obtained with dual control appears to be limited by the exhaust. The reason for this unexpected result is that the amplitudes demanded of the actuators by the controller exceed their capability. This was obvious during the testing because the voltages applied to the actuators could be seem in oscilloscope traces to be clipping, i. The actuator displacement was limited by the maximum voltage that could be generated by the power amplifiers. This occurred rarely when controlling with only inlet error sensors or only exhaust error sensors. The analytical results in Part I correctly predicted that simultaneous control 3 American Institute of Aeronautics and Astronautics would require nearly double the actuator amplitude of control in either the inlet or exhaust alone. What the predictions did not indicate was that the actuator amplitudes demanded would be greater than their capabilities, possibly due to inaccuracies in the modeling. While errors of a few dB may be acceptable for noise predictions, they may not be for determining actuator displacement requirements. For example, a 3 dB discrepancy could lead to over a 40 percent error in actuator amplitude predictions. It may also be that the convergence based on the transfer functions from the initial system identification is more susceptible to error as the size of the matrix increases number of control channels. Passive Treatment Studies have shown that reducing passive treatment to install an active noise control system will result in penalties due to the loss of treatment that may be greater than that obtained from the ANC. A passively treated duct section was installed in the inlet to investigate incorporating passive treatment into an ANC system. Comparisons were made of the ANC performance with baseline hard-wall treated section taped over to ANC performance with the treated section exposed. A comparison was made between the typical method of using the error sensing microphones upstream of the exposed treatment and embedding the microphones in the treatment.

ACTIVE CONTROL OF FAN NOISE BY VANE ACTUATORS pdf

Nasa apollo 11 manual Introduction to Mark People of God Series and Timelines The nonlinear dynamic theory of learning Mas annual report 2016 17 The Netherlands in the European Union. National Intelligencer Newspaper Abstracts, 1848 Founders and leaders John O. Vallandigham. The christian life and warfare watchman nee Treatise upon the poor laws Advanced analytical chemistry books What was medicine like? European space agency annual report Beethoven virus violin sheet Kodak easyshare m380 manual Germs (Great Medical Discoveries) Schools and masters of fence Taking the waking slow Introductory maternity nursing By Boat (Getting Around) The Functional Analysis of Culture Measurement of an electric field due to conduction currents Swimming Shermans 6. Discussion and Implications 128 The epic of Alexandra Lhasa the Holy City Why people misbehave Can Capitalism survive? (Harper colophon books, CN 595) The family circus Film, fashion, and the future. The concept of the palace in the Andes Joanne Pillsbury The Mysterious Hualien (Green Integer, 103) Lost boy music 101 best practices for accounts payable V.Beoge, A.Brown, K.Clements & Capital Asset Management: Tools and Strategies for Decision Making John Duns Scotus: four questions on Mary Practical guide to holistic health Overview of e-commerce framework