Image Cover Sheet

CLASSIFICATION	SYSTEM NUMBER
UNCLASSIFIED	507239

TITLE

MODELLING AND ANALYSIS OF ACTIVE VIBRATION CONTROL OF NAVAL STRUCTURAL COMPONENTS

System Number:

Patron Number:

Requester:

Notes: Paper #36 contained in Parent Sysnum #507203

DSIS Use only:

Deliver to: DK

Modelling and Analysis of Active Vibration Control of Naval Structural Components

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ABSTRACT

Control of structural behaviour is often required in many naval applications. Examples include vibration control of ship machinery and noise suppression in ship and submarine structures. In the marine community, control is traditionally achieved by the use of passive controllers, such as externally attached absorbers or damping materials, which store or dissipate the energy of vibration. However, although passive control is desirable, it is insufficient in itself in preventing excessive vibration or the propagation of disturbances to remote regions of the structure. On the other hand active control techniques, which involve the use of sensors, actuators and control laws, are suitable when the disturbances to be suppressed excite a number of vibration modes or are of an uncertain or evolving character.

This study is concerned with the modelling and analysis of active vibration control of beams and plate structures. The sensors and actuators are made of piezoelectric materials which are bonded on to the surface of the structures. When subjected to mechanical strain the piezoelectric sensors produce an electric potential, which is first amplified using a suitable control law, and then applied to the actuators. The applied actuator electric potential is converted to a mechanical force which is used to control the structure. An integrated finite element based design/analysis tool, called SMARTCOM, has been developed to model the response and control behaviour of actively controlled structures. The method is based on a twenty-node piezoelectric finite element and control algorithms based on the independent modal control strategy and the linear quadratic regulator (LQR). The integrated finite element-control method is applied for simulating the open-loop and closed-loop responses of beam and plate structures subjected to transient loads. The results of the study have shown that SMARTCOM can be efficiently used for the design/analysis of actively controlled naval structural components.