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EXPERIENCES IN THE USE OF ELECTRIC IMPACT EXCITERS FOR SHIP TRIALS

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INTRODUCTION

An intense source of vibration excitation is often necessary, for example to test theoretical concepts for the transmission of vibration in ship structures, and to evaluate the relative importance of different transmission paths from a machine to a ship's hull. Commonly, access to positions of interest is severely limited, so that it is also important that the exciter should be as compact as possible. These basic requirements are well satisfied by electric impact exciters, but the accurate measurement of force input is more difficult than for established techniques based on electrodynamic exciters or calibrated hand hammers. The aim of this paper is to demonstrate some of the ways in which electric impact exciters have been used in ship trials, in order to maximise the quality and quantity of data that could be derived from a limited trials period.

BASIC PROPERTIES OF THE ELECTRIC IMPACT EXCITER

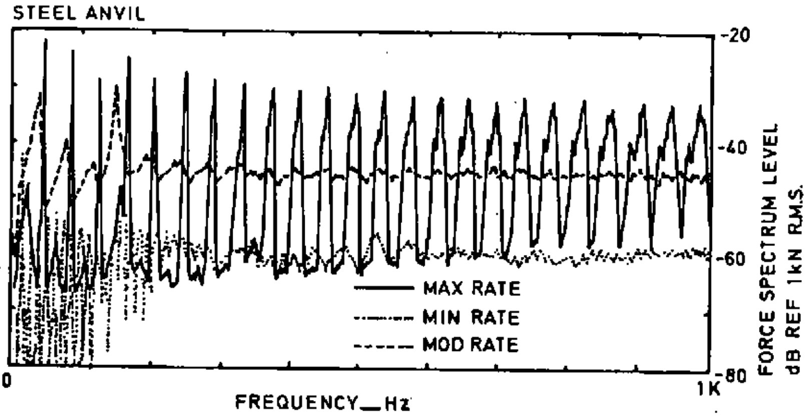
Electric impact exciters (based on [1], [2]) utilise a force gauge or impedance head between an electric hammer and the structure under test. The exciters used by YARD were manufactured by Wilcoxon Research Inc.

They allow control of the number of impacts per second (i.e. impact rate in Hz) and of the shape and magnitude of the force-time pulse that occurs at each impact. Changes in pulse shape are achieved by changing the material of the anvil within the electric hammer. The peak and r.m.s. force levels are about 20 kN and 1 kN respectively when the steel anvil is used, at maximum impact rate. The useful frequency range extends to 10 kHz and beyond. The pulse is much broader and gives a much smaller peak force when a nylon anvil is used. This peak broadening concentrates energy at low frequencies.

Effect of Variation of Impact Rate

The effect of changing impact rate is illustrated in Figure 1, where measured force spectra for the frequency range up to 1 kHz for a steel anvil are compared for nominal impact rates of 10 and 40 Hz, and for a case where the impact rate was modulated between these limits.

Figure 1. Force Spectra



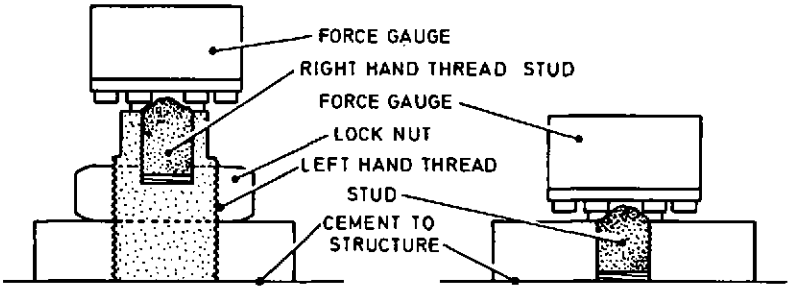
The impact rate tends to drift when the hammer supply voltage is held constant without feedback control of impact rate, owing to changes in lubrication and temperature, so that spectrum peaks have a finite width that increases with frequency. When the frequency is high enough, the averaged spectrum looks like that of white noise. Deliberate modulation of the impact rate causes this smearing effect to extend to lower frequencies, but the rapid change of force input level with impact rate leads to a highly non-uniform average spectrum at frequencies below about 200 Hz.

Attachment of the Exciter to Ship Structures

In order to allow large impact forces to be transmitted, it is usually necessary to cement a substantial steel block to the ship structure and then to attach the exciter to that block using a screwed stud. Figure 2 shows a straightforward arrangement where the exciter is tightened by rotation. Figure 2 also shows an alternative arrangement that utilises left and right handed threads, in order to avoid the need to rotate the exciter body during the tightening operation.

Attachments of this type are needed for adequate excitation of heavy steel structures, but there is a risk that the properties of this structure might be modified by attachment of the exciter, or that the screwed joints will influence the transmitted force. One way of checking that the force gauge signal is an accurate measure of the excitation and that the structure exhibits linear properties, is to measure selected transfer functions using an independent means of excitation.

Figure 2. Methods of Attachment



RESULTS FROM SHIP TRIALS

Calibration Experiments

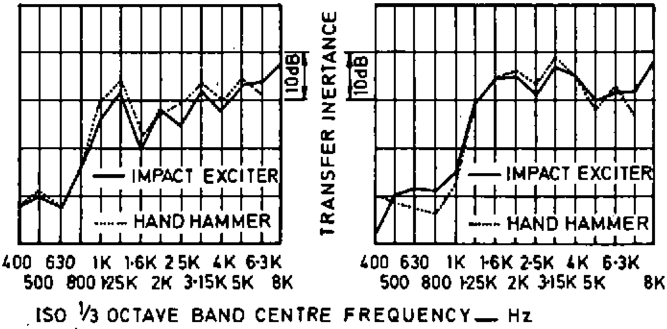
Figure 3 shows typical results that have been derived from exciter trials on massive bulkhead structures. In the experiments, accelerometers were positioned about 1m from the exciter location; close enough to allow signals due to a small calibrated hand-hammer to be detected above background noise, but far enough to ensure that the dynamic range of the accelerometer signal was not exceeded when the impact exciter was used at maximum impact rate. The r.m.s. force level for the two methods of excitation differed by more than 40 dB. In other instances, electrodynamic exciters have been used to obtain an accurately known low amplitude force input, with similar results

The calibration experiments can usually be carried out with minimal disturbance to the ship. Their value in giving weight to time-critical measurements where only the impact exciter provides adequate excitation, such as of transmission to remote locations, certainly justifies the time spent on them.

Use of the Exciter in Reciprocal Experiments

A common requirement is to examine the magnitudes of the forces and moments that are transmitted from a ship system to the hull via flexible mounts, pipe runs, etc. Often, pipes have to be welded to bulkheads for safety and economic reasons and the problem is to identify whether or not this rigid joint causes, or could cause, significant levels of vibration elsewhere in the ship.

Figure 3. Transfer Inertance Measurements



A useful approach to examination of the pipe transmission problem is to generate locally high vibration levels at the bulkhead penetration using an exciter and to measure the vibration attenuation along the pipe run, for different positions and directions of bulkhead excitation. So long as the pipe has low impedances in relation to those of the bulkhead, the force and moment transmissibilities from locations in the pipe system to the bulkhead can then be estimated using the reciprocity theorem.

The advantages of the impact exciter in this context are that it can be used both at locations that would be inaccessible to other types of exciter with adequate force capacity, and when time constraints would otherwise prevent a complete experiment. For this type of measurement it is not necessary to know the exciter force input precisely, as only ratios of induced vibration levels are required. Then, it is sometimes adequate to press the impact exciter against the structure by hand.

ACKNOWLEDGMENT

The work described here was sponsored by the Procurement Executive, Ministry of Defence.

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