SOUND&VIBRATION

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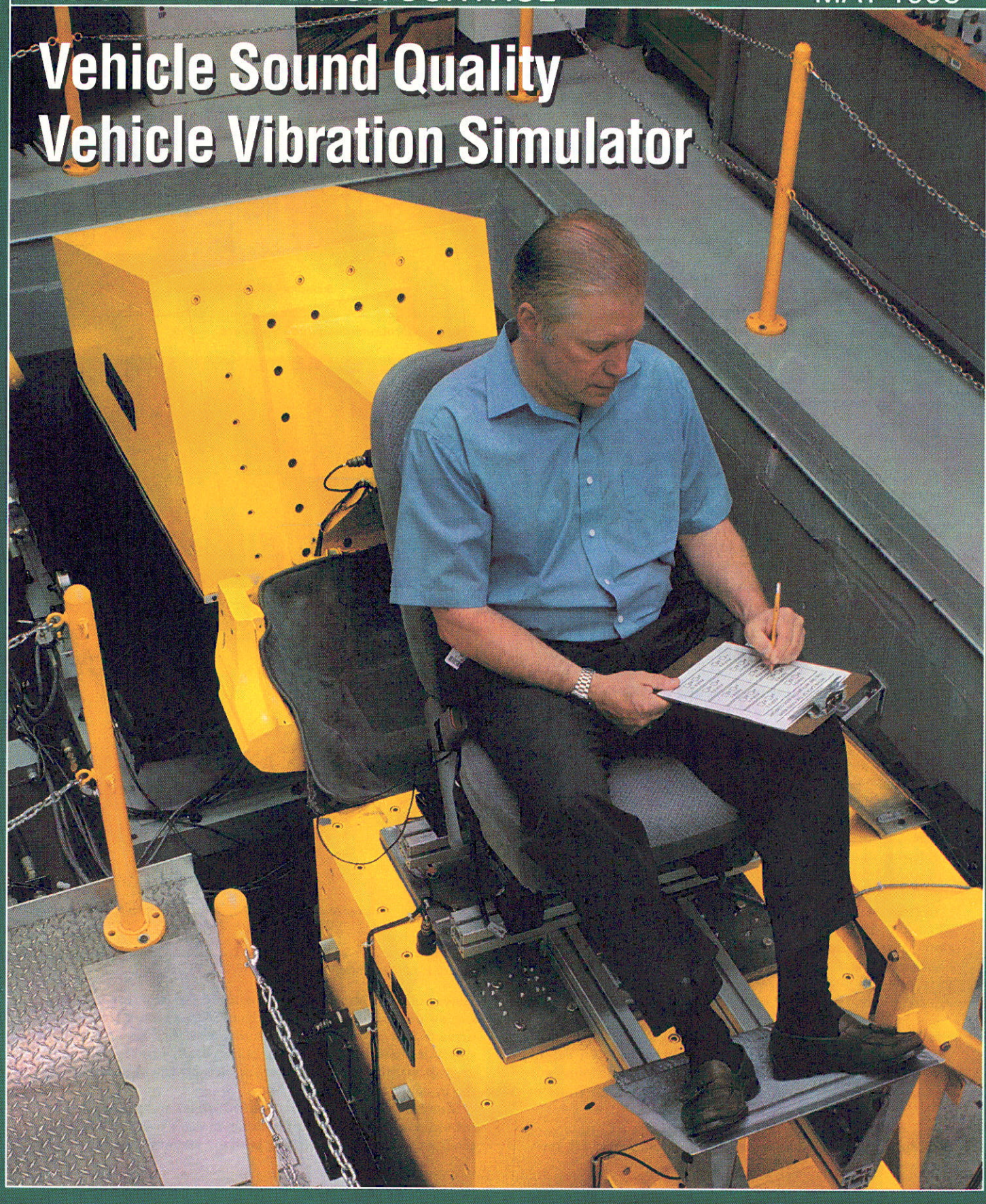
Vehicle Sound Quality Vehicle Vibration Simulator



The Ford Vehicle Vibration Simulator for Subjective Testing

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The development of a vehicle vibration simulator (VVS) for subjective vibration testing is reviewed. The simulator allows evaluation of the ride of a new vehicle design without the enormous cost associated with building an engineering prototype.

Significant progress could not have been made in the sound quality area without the invention and development of engineering tools. For the sound engineer, the binaural recording head is a primary example of one of these tools. The use of the binaural recording head has been crucial to the development of the sound characterization process and has become an essential tool in the Sound Quality areas in Ford Motor Company. A similar tool, The Ford Vehicle Vibration Simulator, has been developed for the vibration engineer. The vehicle vibration simulator (VVS) is unique, consisting of vibration of the vehicle seat (6 Degrees of Freedom), steering wheel (4 DOF), vehicle floorpan section (1 DOF) and the brake or accelerator pedal (1 DOF).

Many vibration test systems have been developed to study human response to vibration, especially for military and space applications. To our knowledge, this is the first multi-axis, fully integrated vibration test system to be used for automotive applications. Initially, the vibration simulator has been used to study vehicle ride and truck idle quality. Vibration time histories measured on different vehicles for a rough road surface and various engine idle conditions were used for playback on the vehicle simulator. Subjective impressions from human evaluators of vehicle ride and idle quality were correlated to objective measures derived from each vibration time history. The purpose of this article is to provide a brief description of the simulator operation, present the detailed results of these studies and discuss potential future applications for the VVS system.

Background

Ford has been a pioneer in the sound quality field. Several papers have been published[1,2] describing the sound quality process and methods developed by Ford Research. This process begins with the gathering of in-vehicle sound data through the use of a binaural recording head. The recordings are then used for 'playback' to obtain subjective ratings as well as analyses for objective measures. A statistical analysis is performed to determine the correlation between the subjective and objective measures. This method has provided the most significant solution to the complex problem of translating customer 'wants and needs' into actual engineering specifications which can then be applied in the vehicle development process.

In June of 1993, funding was obtained and a project was started to develop a vehicle vibration simulator so that the sound quality process could be applied to vehicle vibration. Figure 1 shows the vibration and sound quality process. In order to apply the same process to vehicle vibration, an analogy to the recording head had to be developed.

The Ford Vehicle Vibration Simulator (VVS)

Figure 2 shows the major components of the Ford Vehicle Vibration Simulator (VVS). Hydraulic shaker systems were designed and developed to provide motion to the vehicles'

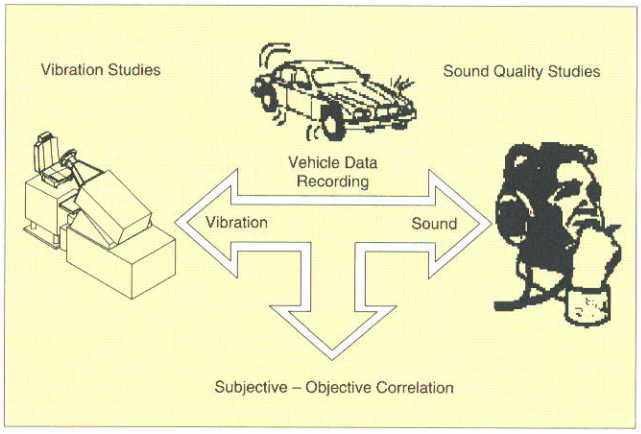

Figure 1. Vibration/sound quality process.

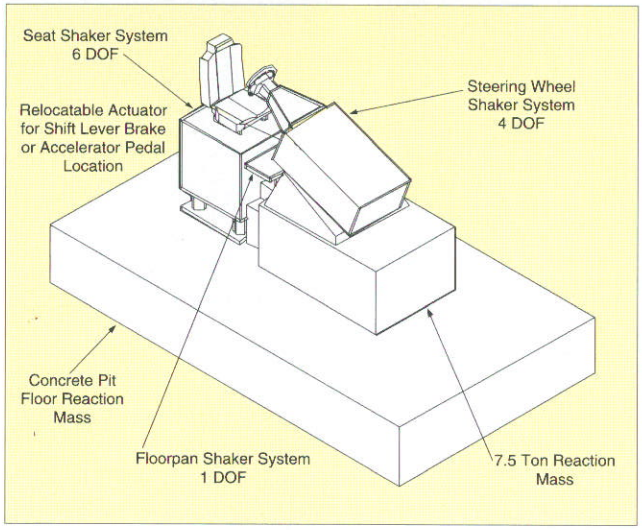

Figure 2. Major components of VVS.

major points of human contact, namely: the vehicle seat, steering column and a section of the floorpan underneath the driver's feet. A relocatable actuator was incorporated in the simulator design to be used for other possible points of human contact with the vehicle interior such as: the shift lever and the brake or accelerator pedals.

Simulator Design. A common industrial hydraulic actuator provides a single degree of freedom motion (vertical only) for the floorpan section. However, both the seat and steering wheel

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