EXPERIMENTAL TESTING OF INTAKE MANIFOLD NOISE

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INTRODUCTION

There are a large number of moving parts and associated processes involved with the operation of a modern day internal combustion powered vehicle significantly contributing to the amount of noise heard within the passenger compartment of the vehicle. Many improvements to vehicle design have been made in recent years to improve overall sound levels produced. Examples of these are stiffer and better acoustically insulated bodies and quieter muffler systems. This, however, has resulted in other potential noise sources, induction noise in particular, becoming more noticeable. The objective of this project was to develop an experimental model that would simulate the pressure pulses which propagate through a production intake manifold under operating conditions. Development of this model would provide a tool to facilitate future research in areas that are currently difficult or impossible to achieve with other experimental or numerical techniques.

METHOD

The experimental simulator developed consisted of an intake manifold from a Chrysler Neon which had a dynamic speaker mounted to each of the four runners of the manifold. Intake pressure data taken from Ricardo Wave, a noise modelling software package, was digitized and stored on a personal computer. A program written with Labview, a data acquisition software package, would read the pressure data and convert it to four channels of output voltage to be sent to each of the four speakers in the same sequence as the firing order of the engine. A microphone located 5 centimetres above the throttle body would then pick up the manifold noise output and send this signal back to the computer. The Labview program would digitize the signal and output the measured results in a time domain and frequency domain format for analysis. Manifold noise measurements were also made of an actual Neon engine motored on a dynamometer and stored on a digital audio tape. This information was fed into the same analysis program used before which would again output the time and frequency domain results of the intake manifold.

RESULTS

To ascertain the validity of the output produced by the experimental model, the measurements amassed from the simulation model were compared to the same measurements performed on both the actual Neon engine and to the outcome as predicted by the theoretical Ricardo Wave model. The two data types used for comparing the results of the three output sources were the time domain signal and the frequency domain signal. It was found that the time domain signal for the theoretical and actual engine results were very similar. Both sources produced the same characteristic peaks and troughs with similar amplitudes as the same corresponding engine crank angles. Comparing these curves to the output produced by the experimental simulator illustrated similar correlations with the addition of some sub-peaks preceding the beginning of each of the four combustion cycles of the engine. It is suspected that these are the result of non-lineararities in the performance of the speakers used to produce the simulated pressure pulses at the manifold runner openings. In addition to the above qualitative assessment, a quantitative evaluation comparing the simulation results to the measured results from the actual engine was pursued using statistical parameters. Specifically, the calculated mean, standard deviation, correlation coefficient and covariance was determined as illustrated in Tables 1, 2 and 3. It can be seen that the two sets of data have similar central tendencies as well as dispersion about the mean. Perhaps the most convincing affinity between the two sets of data

Table 1: Mean and Standard Deviation for Modelled and Actual Manifolds

Statistical Evaluation	Data Source	
	Simulation Model	Actual Engine
Mean	-0.02	0.01
Standard Deviation	0.58	0.45

Table 2: Correlation Matrix

	Simulation Model	Actual Engine
Simulation Model	1	-
Actual Engine	0.6	1

Table 3: Covariance Matrix

	Simulation Model	Actual Engine
Simulation Model	0.34	-
Actual Engine	0.16	0.21

lie within the correlation and covariance analysis which demonstrate good correlation with similar trending of the data curves. For the analysis of the frequency domain signal, all three sources produced nearly identical results for a given engine rpm. The results showed that for an engine rpm of 2400, all the outputs produced a fundamental frequency of 80 Hz followed by a second and third harmonic frequency of 160 and 240 Hz respectively. These results further reinforce the correlation of the experimental results with the theoretical and actual engine results.

CONCLUSIONS

Given a theoretical input signal at the interface between the intake manifold runner and engine head, it has been shown that it is possible to reproduce these pressure pulses. Analysis of the time domain signal for the actual engine compared favourably to the theoretical time domain signal thus validating the use of either source as a reference for comparing experimental results. Also, the statistical parameters determined for the experimental and actual time domain signals compared favourably. It is suspected that any differences are the result of non-lineararities in the low frequency operation of the speakers. The frequency distribution of all three sources were very similar thus further reinforcing the validity of the experimental simulation.

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