inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 79

NEVER MIND THE LEVEL LISTEN TO THE QUALITY

A Bennetts & P Stringer

Index Data Systems Ltd, Scarborough, UK

1. INTRODUCTION

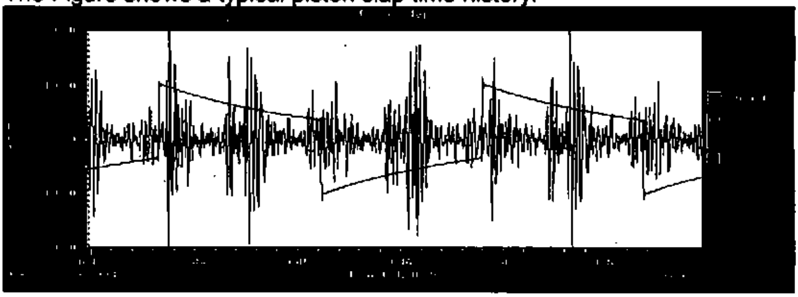
If the product is capable of some mechanical movement, be it a food mixer or an automobile, then Noise and vibration or rather the lack of them will play an important role in a prospective customer choosing to buy. Reduction in noise levels is desirable but may not improve a customers perception of the product, masking of annoying noises may become reduced and hence good money may be spent revealing noises which cause greater annoyance. This paper shows how the causes of annoying squeaks and rattles in diverse products can be identified and how noise recordings can be processed to isolate the annoying noises. The final section notes the array of Metrics available to label the "quality" of sound and shows how difficult it is to use such metrics to accurately trap the unwanted noises.

2. EXAMPLES

Piston Slap

The internal combustion engine is prone to make a variety of unpleasant noises, this is particularly true when cold. Pistons hitting the bore walls as they accelerate downwards following the ignition of the air/fuel mixture is a particularly distressing sound for a new owner to hear! Should such noises persist it is reasonable to expect the customer to call in on their ever helpful and long suffering garage service manager for a full and frank discussion on the merits of their particular vehicle. The motor manufacturers commitment to satisfied customers is such that this meeting should never happen and therefore noise due to piston slap should be completely suppressed. To achieve this worthy goal it is first necessary to capture and analyse the nature of the problem, it is here that we can use our knowledge of signal processing to isolate the noise and hence begin to understand the manner of its generation.

The Figure shows a typical piston slap time history.

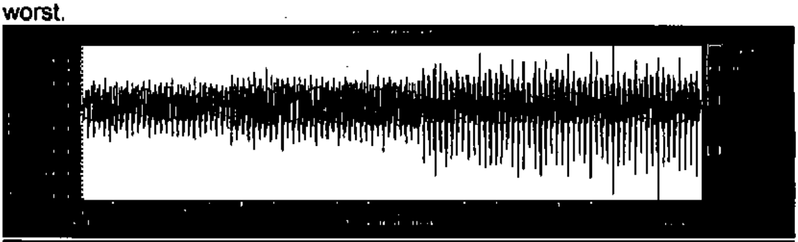


Time between top dead centres for No. 1 cylinder power stroke 0.02957 seconds. Instantaneous engine speed = 4058.16 rpm. Delay of slap behind No. 1 TDC is 0.001094 seconds, i.e. a crank angle of 26.638 degrees.

The ability to listen to each of the pistons and to determine which is the cause of the problem can be the seed from which a full explanation as to why some engines / cylinders exhibit particularly bad performances and why some seemingly identical are acceptable. For this angle domain editing to take place a special algorithm was developed to lift specific time samples from the continuous data stream. This new time history is not simply one cycle repeated but one cylinders signature extracted from the complete 20 second time history.

Injector Noise

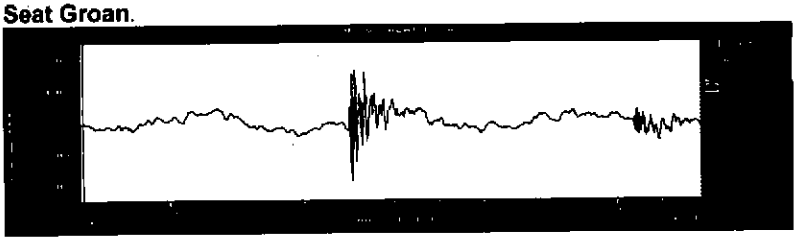
The following data is an under hood recording made using a standard microphone of the noise variation created by changing diesel injector pumps. It is immediately apparent from inspection that the noise signatures are different, the peaks are higher, the auditory response is even more definite however and there is seldom disagreement as to which is the worst.



Window Rattle and Seat Groan

When a product such as an automobile is assembled literally 1000's of components come together, inside the cabin alone there are hundreds of items and miles of wiring hiding behind the dash board/crash pad. It is perhaps little short of a miracle that when subjected to the best efforts of the Highways Agency's road system that the whole assembly does not rattle, buzz and squeak continuously. In fact the modern car typically suffers from very few irritating noises, unfortunately the absence of such makes the presence of one a point of immediate customer irritation. Disturbing complex trim at the dealerships to solve this type of problem is not the desired solution as trim disturbed is trim destined to rattle and squeak in the future. The solution is the detection before the vehicles leave the plant and the rectification of the defects and the improvement of the assembly techniques to the point where such problems do not arise during normal production. The following two cases show how annoying rattles and groans were successfully isolated in the noisy background of an auto plant.

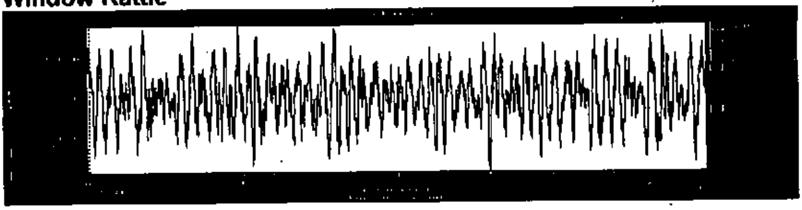
Seat Groan.



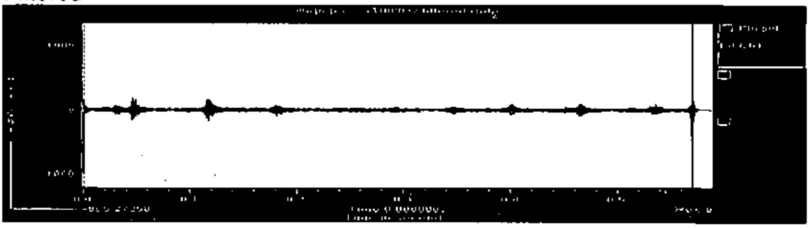
Now high pass filtered.

After filtering it is a straight forward matter to threshold and detect the groan.

Window Rattle



Filtered



3. METRICS

A selection of available, defined metrics:
Loudness DBA (B/C), Sound pressure level (SPL), Speech interference level(SIL), Spectral Balance (AI), Composite rating of preference CRP), Kurtosis, Roughness, Boom, Harmonic content, Irregularity

These all perform the same basic function, which is the description of the audio wave form by a simple number. Any given signal when analysed will produce an array of numbers defined by the above metrics. These numbers can then be used to define the differences between sounds. At present our work is focused on the continuing development of a meaningful and easy to use set of metrics. Progress to date will be shown at the conference and published in later papers.

4. CONCLUSIONS

It has been possible to see and hear the differences between various noises, it is also clear to anyone who has had to work with them that Metrics are in general cumbersome and potentially difficult to use as a basis for making engineering decisions. Unfortunately they are the only language that we have to describe sounds and therefore we must continue to develop the vocabulary until it becomes a usable language.