

RH LYON CORP

Leader in Quiet Product Design and Diagnostics

Winter 2003/4

NEWSLETTER

Vol. I, No. 2

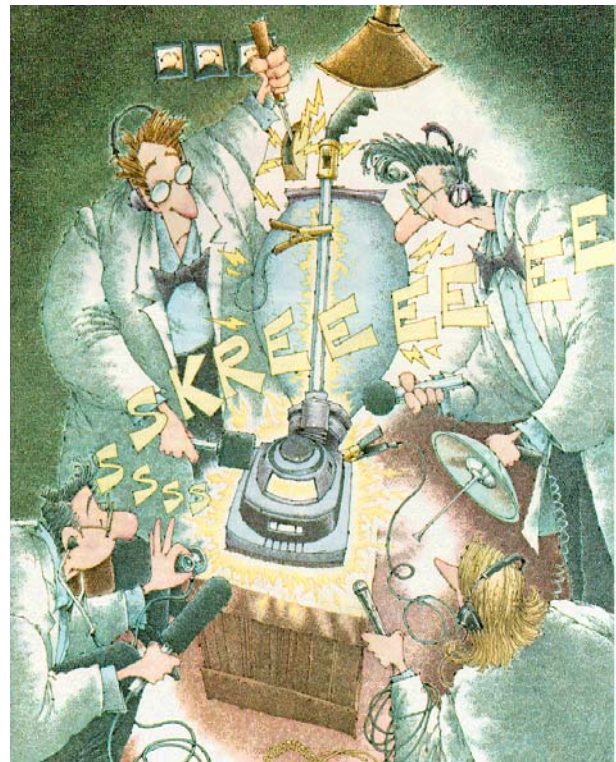
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Sound and Vibration - Useful Product Diagnostics

Most of us are aware of how much we use sound to tell how well a product is working. An unexpected rattle in a car door or a rubbing noise in a VCR will catch our attention even if the sound is faint, because the product shouldn't be making that noise. But even sounds that we expect, like the growl and whine of a garage door opener, can cause concern if they are too loud, signaling in our minds a problem or defect.

A trained auto mechanic can often use the sounds of an engine to tell not only that there is something wrong, but also *what* is wrong with the engine. Obviously, sound and vibration relay a great deal of information. For this reason, they have been heavily exploited in the development of diagnostic systems which either monitor the health of the product while in use or detect flaws introduced during manufacture. But the process of replacing an experienced listener (our auto mechanic) with an automated system is far from simple because it is difficult to sort out those features of the signal that the listener has keyed

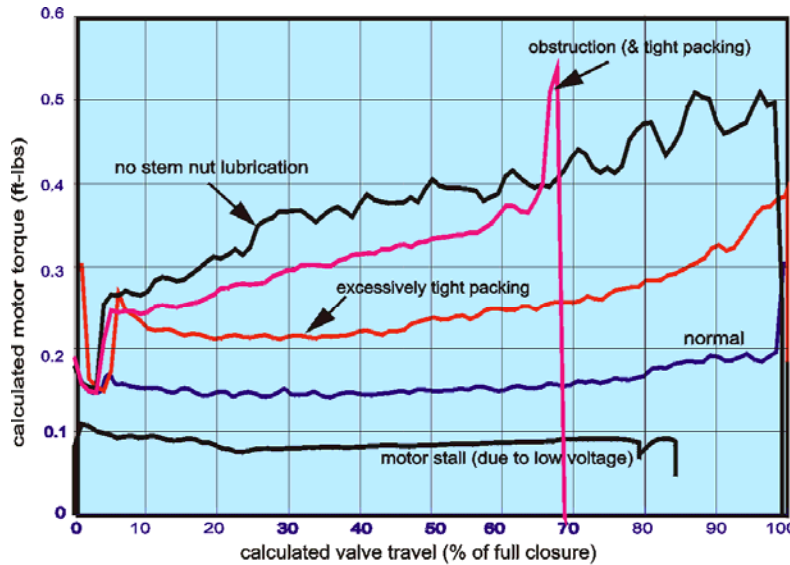


Illustrated by Jeff Seaver

into. These features can be subtle in comparison to others which might appear to be more prominent.

Diagnostics of products during use. Until recently, so-called “in-service” diagnostics had tended to be reserved for products that were ex-

motor torque, in addition to monitoring vibrations to measure the meshing of gear teeth, and therefore motor rotations and valve travel. A plot of motor torque vs. valve travel, like those shown in the figure to the left, is a diagnostic “signature” that can be used not only to identify deteriorated valves, but also to give an indication of what has caused deterioration (poor lubrication, bent valve stem, tight packing, etc.).



Torque vs. travel signatures for different faults

Diagnostics of products during production.

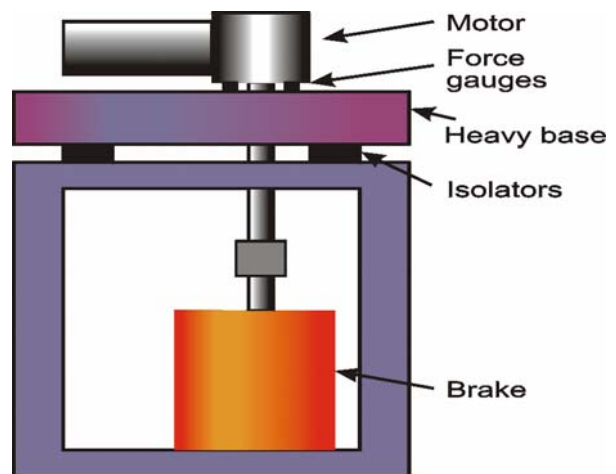
When diagnostic systems are incorporated into the production line, they can generally be more extensive and expensive. This is true even if the product is not costly, because time saved in diagnosing a production glitch can save large amounts of money through increased productivity. Systems that simply reject items based on too much noise or vibration are less cost-effective than those that can identify the actual defect. This additional information will usually point to a production process problem that needs to be fixed.

pensive or used in critical applications. With the pervasiveness of the internet, product diagnosis is moving rapidly toward web-based monitoring, even of the most basic appliances. RH Lyon Corp has a rich history of involvement with “in-service” diagnostics, especially for internal combustion engines and the motor operated valves (MOV’s) used extensively in both nuclear-steam and ordinary power plants.

Thirty years ago, while at the Massachusetts Institute of Technology, Richard Lyon began to sort out the pertinent vibration signals buried amidst the “clatter” of a diesel engine which results from the rapid onset of combustion in each cylinder. That work was expanded to other types of engines and continues today, in collaboration with TIAX LLC of Cambridge, MA, with the detection of the start of combustion in HCCI (homogeneous charge compression ignition) engines.

Motor operated valves, critical to power plant operation, have been singled out by the Nuclear Regulatory Commission for special attention by plant operators. Our MOV diagnostic procedure involves monitoring voltages and currents applied to the motor to derive instantaneous

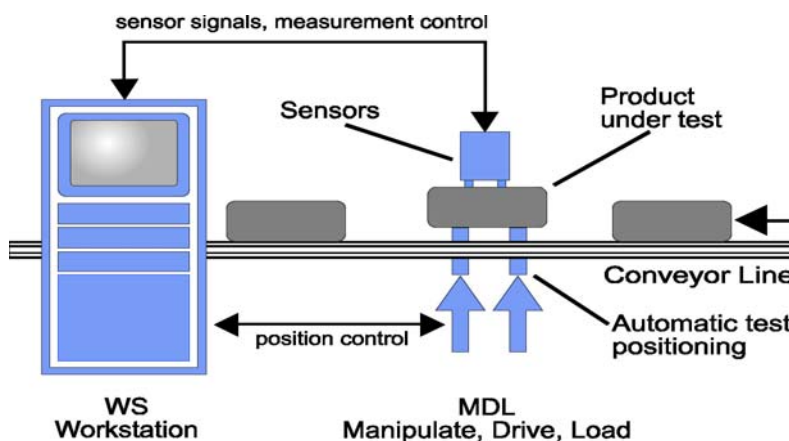
At RH Lyon Corp we have designed such an in-depth system useful for diagnosing problems in automobile windshield wiper motors. The diagnostic system identifies several “signatures” based on the analysis of both electrical and vibration signals, which create a set of indicators for problems encountered in the manufacturing of wiper motors. In general, there is not a one-to-one correspondence between indicators and faults, but specific faults have been identified by



Wiper Motor Test Fixture

establishing a unique pattern of indicators. This greater in-depth analysis is just as quick as the simple pass-fail vibration *threshold method* commonly used, but the information gained and the resulting increase in productivity is much greater.

The mandate for another production line system that we developed was to detect a particular gear whine problem in the motor drive of golf cars. In the assembled product, modulated gear whine (a sort of “wow-wow-wow”) would occur, leading the OEM to reject the drives. A special test fixture and signal processing station were developed that would subject the drives to varying loads (coasting, braking, accelerating) and measure their noise in the process, as illustrated below. A signal processing algorithm was designed to detect the unique modulation since that was the specific characteristic of the sound that was objectionable.



Typical Layout of SignaTrack

But production line diagnostic systems are not always complicated and expensive. One company was making small sintered metal parts in large numbers. These parts were used in a product that required they withstand a large number of repeated impacts and not fracture or fatigue. Most of the product met the requirement, but parts from some batches would fail after a very short time. A diagnostic procedure was needed to detect the change in the production process that made this difference. The amount of powdered metal in each part was the same, so the mass of the part was well controlled. It was the stiffness of the part, sensitive to the sintering process – pressure, temperature, and duration – which was changing. The varia-

tion in stiffness could be measured by applying a basic acoustics principle that says resonance frequencies are determined by the stiffness-to-mass ratio. Stiffness (and thus acceptability) was determined by measuring the frequencies of their vibrations while allowing the parts to bounce off a fairly rigid surface as they passed by a microphone. This test, simple but effective, has been able to separate the good from the faulted product, and flag an out of control sintering process.

European Directives on Product Noise

While a national noise policy has been in limbo in the United States since the ‘80’s, the countries of Europe through their European Union (EU) have been making significant progress in implementing their own noise policy. For example, in 2002, sixty different types of equipment for outdoor use had to be labeled for their *guaranteed product noise levels* in order to be sold within the European Union. Construction equipment and lawnmowers must not only be labeled, but the amount of noise they can generate is limited. Manufacturers have been informed that more stringent noise requirements on a much broader range of products will follow (see table on following page).

The promulgation of these European Directives on product noise for construction and commercial lawn care equipment has raised significant issues of international trade and technology for US industry. US companies are finding it more difficult to manufacture and sell their products in Europe as a result. Meeting the noise limits in a cost effective manner while continuing to supply a well-performing product to customers requires technical changes. US companies could decide not to meet the EU requirements and turn to legal and political means to try to force the EU to relent, but that approach is not likely to be successful. Companies that are able to meet the requirements will have a competitive advantage. Global markets will follow the EU lead. When the Asian market falls in line with the EU, as is likely in the near future, the EU requirements will become global. Companies cannot decide to

Table of Limit Values

Type of equipment	Net Installed Power P (in kW) Electric Power P _{el} in kW Mass of Appliance m in kg Cutting Width L in cm	Permissible sound power level in dB / 1 pW	
		Stage I as from 3 January 2002	Stage II as from 3 January 2006
Compaction machines (vibrating rollers, vibrating plates, vibratory hammers)	P ≤ 8	108	105
	8 < P ≤ 70	109	106
	P > 70	89 + 11 lg P	86 + 11 lg P
Tracked dozers, tracked loaders, tracked excavators-loaders	P ≤ 55	106	103
	P > 55	87 + 11 lg P	84 + 11 lg P
Wheeled dozers, wheeled loaders, dumpers, graders, loader-type landfill compactors, combustion-engine driven counterbalanced lift trucks, mobile cranes, compaction machines (non-vibrating rollers), paver finishers, hydraulic power packs	P ≤ 55	104	101
	P > 55	85 + 11 lg P	82 + 11 lg P
Evacuators, builder's hoists for the transport of goods, construction winches, motor hoes	P ≤ 15	96	93
	P > 15	83 + 11 lg P	80 + 11 lg P
Hand-held concrete breakers and picks	m ≤ 15	107	105
	15 < m < 30	94 + 11 lg m	92 + 11 lg m
	m ≥ 30	96 + 11 lg m	94 + 11 lg m
Tower cranes		98 + 1g P	96 + 1g P
Welding and power generators	P _{el} ≤ 2	97 + 1g P _{el}	95 + 1g P _{el}
	2 < P _{el} ≤ 10	98 + 1g P _{el}	96 + 1g P _{el}
	P _{el} > 10	97 + 1g P _{el}	95 + 1g P _{el}
Compressors	P ≤ 15	99	97
	P > 15	97 + 2 lg P	95 + 2 lg P
Lawnmowers, lawn trimmers/lawn edge trimmers	L ≤ 50	96	94
	50 < L ≤ 70	100	98
	70 < L ≤ 120	100	98
	L > 120	105	103

serve only a limited market, particularly in consumer products, since the economies of scale will allow successful companies to out-develop and undercut a competitor with a small market share. Companies that cannot compete abroad will be in danger of being out-designed and undercut in price, with the loss of markets both abroad and at home. For more information on the EU Directives and their timetable contact Dick Lyon at RH Lyon Corp.

RH Lyon Corp News

In the Spring 2003 issue of this Newsletter, the development of SQSys™, a system for the determination of the sound quality of products, was described. The company is actively seeking

partners to make this system a viable product and bring it to market. This Newsletter notes that we are cooperating with TIAX LLC in the development of a system to determine combustion onset timing for HCCI and other internal combustion engines.

Through projects funded internally and by the government and industry, RH Lyon Corp is currently developing several product concepts and prototypes in the areas of active control, noise and vibration based diagnostics, vibration measurements, and mapping of underground chambers. We are seeking industrial partners to carry forward the prototyping, manufacturing, and marketing of these products. Contact Dick Lyon at <lyoncorp@lyoncorp.com> for more information.