MICHIGAN STATE
UNIVERSITY

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To: Whom It Concerns

Attached is the Michigan State University, College of Engineering Dynamics and Vibrations Laboratory report on the effects of VIBEX (a damping product manufactured by Permawick Corporation) on the MTD/Wolf Garten line trimmer.

The report contains results from tests that were conducted by Michigan State University. Permawick Corporation will share the findings with MTD/Wolf Garten. It was found that VIBEX sport (20% lighter than the traditional Vibex used in other systems) has a positive effect on reducing vibrations in the handle bar of a line trimmer during operation. (Henceforth through the report we use VIBEX, VIBEX sport interchangeably.)

Sincerely,

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COLLEGE OF
ENGINEERING

Department of
Mechanical Engineering

VIBEX Testing in a MTD/Wolf Garten Line trimmer

Test conducted at Vibrations Lab @ MSU, East Lansing

December 11, 2011

Project Description:

Based on recent interest shown by MTD to reduce vibration in their line trimmer, it was decided to test operational vibration levels in a line trimmer with and without VIBEX. It is desired to show that VIBEX has the same dampening effects on a line trimmer as has been observed with other products in the industry, and to study the extent of vibration reduction across a range of frequencies. Results of the test are to be provided to Permawick Corporation.

Equipment:

- Wold Garten line trimmer
- 6 shear-type accelerometers (352B10/10AC) manufactured by PCB Piezotronics
- 16 channel signal conditioner (481A02) manufactured by PCB
- Eight 2-channel AR GXPA TEAC modules for data recording manufactured by Tritech
- Gateway Laptop w/ required software for post processing data (TEAC GX Navi and Matlab)

Procedure:

Two test configurations were considered for the case of the line trimmer. The first test configuration was with free boundary conditions. The line trimmer was suspended with rope/elastic supports and impacted with hammer. This provided information regarding the natural frequencies of the system. The second configuration was under actual operating conditions. The line trimmer was held by a person while in running condition and data was recorded using accelerometers. The accelerometers were placed at the locations shown in Figure 1. Figure 2 shows the conditions under which the running tests were done.

Data from the running tests are considered for preparing this report. Five sets of data were recorded for each test. Data was sampled at 5000 Hz with the low pass filter set to 2000 Hz. VIBEX was placed at the locations shown and inserted directly using air powered caulking gun.

In the lower handle, about 28g VIBEX was inserted (see figure 3). In the lower leg section of the unit, about 42g VIBEX was inserted (shown in figure 1).

Figure 1: (left) VIBEX locations and (right) sensor locations for the line trimmer

Figure 2: Line trimmer in test 2 configuration (sensor position as shown)

Figure 3: 28 grams of Vibex sport inserted at the handle

Results for Test Configuration 2 (operating condition):

For this configuration, the line trimmer was held in the air by a person (and not "trimming") as it would be while in use. The vibration experienced by the user was then caused by the excitation induced by the motor. This would be the closest estimate of the actual vibration conditions.

Steady operation of the line trimmer motor likely corresponds to nearly periodic excitation, with a fundamental frequency and harmonics (possibly including sub harmonics). In a linear system, periodic excitation leads to a periodic response at the same frequencies. In contrast, the impact excitation induces response components at all frequencies. This could be obtained by running tests in configuration 1 for more detailed understanding of the natural frequencies of the line trimmer.

The result for the vibration response under the running condition is discussed below.

Figure 4 below shows the fast Fourier transform (FFT) of the data collected. On the horizontal axis is the frequency, which is the rate of oscillation in cycles/second (Hz) units. The vertical axis displays the amplitude associated with a given frequency in the signal. The figure shows that the response at multiple frequencies when excited during operation. The motor operates at a nearly constant rate, and harmonics of the motor operation speed lead to harmonics in excitation, and therefore harmonics in response.

The blue lines represent the tests without VIBEX, red lines represent tests performed with VIBEX at the handle, magenta lines represent VIBEX in the legs and green represents VIBEX at both locations. Individual testing of VIBEX at different locations was made possible because of two line trimmers provided by MTD/Wolf Garten.

For the case of sustained excitation, the reduction in the peak can mean that the magnitude of the vibration is reduced. It can be seen at the excitation frequencies in Figure 3 that there is a reduction in vibration response. The exact percentage of reduction is shown in Table 1. All the sensors show excellent reduction in overall vibration levels of the line trimmer. The measured locations near the handles at sensors 3,4 and 6 show an average reduction of 51.97%, 74.03% and 75.16% respectively.

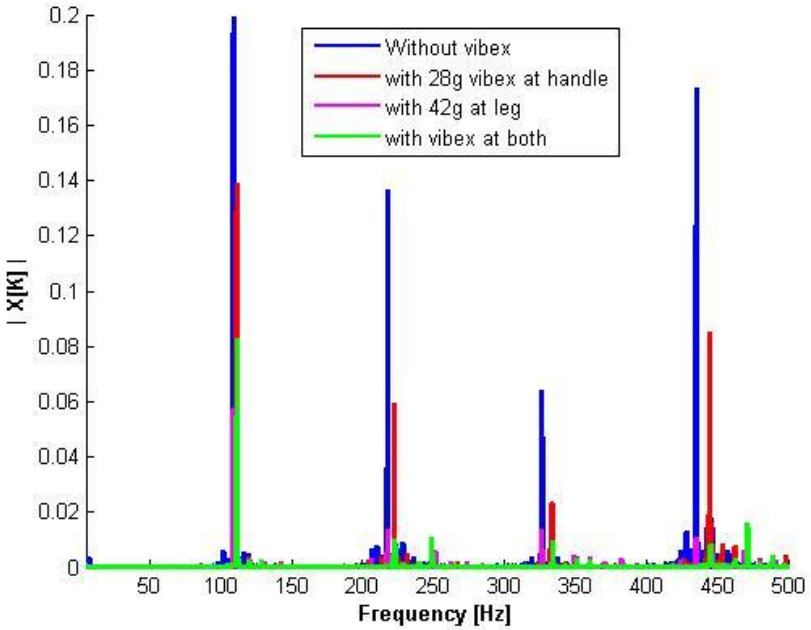

Figure 4. FFT of all sensors during operation of the line trimmer

Table 1: Maximum Amplitudes at Main Frequencies

		110Hz		221Hz		331Hz		441Hz	
Sensor1	Without VIBEX	0.1298	×	0.1365	×	0.0488	×	0.1733	×
	28g at handle	0.0426	-67.23%	0.0596	-56.32%	0.0164	-66.35%	0.0850	-50.96%
	42g at leg	0.0133	-89.79%	0.0107	-92.18%	0.0064	-86.80%	0.0075	-95.65%
	Both	0.0183	-85.94%	0.0074	-94.61%	0.0070	-85.64%	0.0023	-98.65%
Sensor2	Without VIBEX	0.1990	×	0.0402	×	0.0285	×	0.0186	×
	28g at handle	0.1389	-30.22%	0.0088	-78.05%	0.0122	-57.01%	0.0073	-60.91%
	42g at leg	0.0575	-71.09%	0.0139	-65.38%	0.0132	-53.69%	0.0020	-89.35%
	Both	0.0829	-58.32%	0.0093	-76.87%	0.0032	-88.88%	0.0026	-86.28%
Sensor3	Without VIBEX	0.1318	×	0.0172	×	0.0063	×	0.0793	×
	28g at handle	0.0685	-48.01%	0.0026	-85.08%	0.0083	32.10%	0.0531	-33.02%
	42g at leg	0.0284	-78.42%	0.0051	-70.49%	0.0028	-55.13%	0.0111	-86.06%
	Both	0.0684	-48.09%	0.0073	-57.46%	0.0067	7.25%	0.0086	-89.17%
Sensor4	Without VIBEX	0.1215	×	0.0450	×	0.0181	×	0.0339	×
	28g at handle	0.0248	-79.56%	0.0245	-45.62%	0.0084	-53.49%	0.0121	-64.22%
	42g at leg	0.0280	-76.93%	0.0060	-86.63%	0.0075	-58.63%	0.0043	-87.35%
	Both	0.0372	-69.37%	0.0074	-83.57%	0.0016	-91.16%	0.0028	-91.83%
Sensor5	Without VIBEX	0.0158	×	0.0334	×	0.0513	×	0.0830	×
	28g at handle	0.0293	85.59%	0.0279	-16.48%	0.0141	-72.55%	0.0353	-57.52%
	42g at leg	0.0089	-43.51%	0.0055	-83.49%	0.0096	-81.22%	0.0083	-89.97%
	Both	0.0164	3.83%	0.0100	-70.02%	0.0095	-81.53%	0.0043	-94.83%
Sensor6	Without VIBEX	0.0660	×	0.0830	×	0.0638	×	0.0906	×
	28g at handle	0.0120	-81.83%	0.0380	-54.19%	0.0228	-64.24%	0.0464	-48.81%
	42g at leg	0.0304	-53.98%	0.0131	-84.23%	0.0137	-78.47%	0.0064	-92.92%
	Both	0.0261	-60.37%	0.0028	-96.62%	0.0061	-90.48%	0.0039	-95.74%

Summary:

- VIBEX significantly reduces the vibration in the handles during running test, which simulates the operating condition of a line trimmer.
- The response amplitudes at excitation frequencies 110Hz, 220 Hz, 330Hz and 440 Hz are all reduced by an average of 66.52% across all sensors.

Things to Note

- The location of accelerometers and hand support while holding the line trimmer to keep it in the running condition has an influence on the responses read by the accelerometers. Care was taken to ensure very similar sensor locations on tests with and without VIBEX, and the location error is assumed to be negligible.
- The tests were plotted for frequencies less than 500 Hz. Higher frequencies can be examined if desired.
- Test configuration 1 (impact tests) has also been performed to assess the natural frequencies of the system and VIBEX shows appreciable reduction in vibration.

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