HAND-TRANSMITTED VIBRATIONS OF PNEUMATIC GRINDERS SUSPENDED FROM A MECHANICAL ARM SYSTEM

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Introduction

Shipyards and other construction and manufacturing establishments that require the extensive use of heavy powered hand tools have introduced the use of counterweighted mechanical arm systems to alleviate mechanical stressors on tool operators. Preliminary shipyard trials suggest that by reducing the stressors associated with certain tool operations, these ergonomic interventions may increase productivity rates by 50% or more for tasks such as overhead grinding. While the results of our earlier study[1] on the use of pneumatic grinders in conjunction with a counter-balanced mechanical arm indicated that the arm offered small to moderate reductions in hand-transmitted vibration (HTV), the reduced HTV exposures can be offset by increases in work cycle times; these interventions may actually increase daily HTV exposures in some cases. In the present study, we completed some preliminary evaluations of the effects of adding suspension mechanisms to the mechanical arms on grinder vibrations in a simulated work task.

Methods

In this laboratory study, two pneumatic grinder models were operated under four support conditions in a simulated work task based on ISO 28927-1 (2009).[2] The grinders were suspended from an Equipois zeroG4 mechanical arm with either a latex band, a vinyl-coated braided steel cable, or the Equipois gimbal system. The three suspension mechanisms are shown in Figure 1. The grinders were also operated in free air with no support. Tri-axial acceleration was measured simultaneously at both tool handles while the grinders were operated at full speed. In this simulated work task, the grinding disks and flaring cup wheels were replaced with unbalanced aluminum wheels as specified in the ISO standard[2] (Figure 1). The grinder operator stood on a force plate and applied a feed force of 30 N (except in the trials with the unsupported tools). Eight tool operators completed five 10-s trials for each tool/support condition combination.

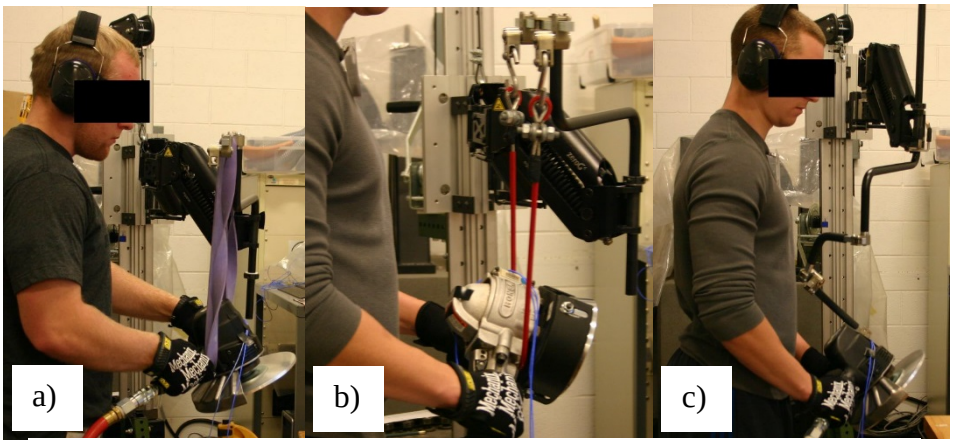

Figure 1. The three suspension mechanisms: a) latex band; b) vinyl-coated braided steel cable; and c) gimbal system. The tools were also operated without support.

Results and Discussion

The means for unweighted and frequency-weighted accelerations measured at the left and right grinder handles are listed in Table 1 along with the average percentage reduction in acceleration afforded by the three suspension systems. As indicated, the right handle exhibited significantly lower vibration than the left handle in all conditions except when the mechanical arm's gimbal system was used. All three suspension techniques produced small to moderate reductions in vibration when compared to the unsupported condition. The gimbal system showed the greatest reductions in acceleration at the left tool handle, but was the least effective at reducing vibration at the right handle. This is likely because the gimbal system is attached to the left tool handle. Figure 2 shows the average frequency spectra for the left and right handles for one of the grinders. As can be seen, none of the suspension systems was effective at reducing vibration in the middle frequencies (50–250 Hz). The spectra for the other grinder were similar.

Table 1. Mean unweighted and frequency-weighted accelerations for the left and right tool handles of the two grinders along with the percent reductions in acceleration for the four support conditions.

	Unweighted Acceleration				Weighted Acceleration			
	Left Handle		Right Handle		Left Handle		Right Handle	
Support condition	m/s^2	% Reduction	m/s^2	% Reduction	m/s^2	% Reduction	m/s^2	% Reduction
No Support	41.81	-	29.62	-	3.17	-	2.92	-
Latex Band	34.93	16.4	28.39	4.1	3.00	5.4	2.78	5.0
Steel Cable	33.79	19.2	27.72	6.4	3.02	4.7	2.70	7.5
Gimbal	29.39	29.7	29.21	1.4	2.85	10.0	2.81	3.9

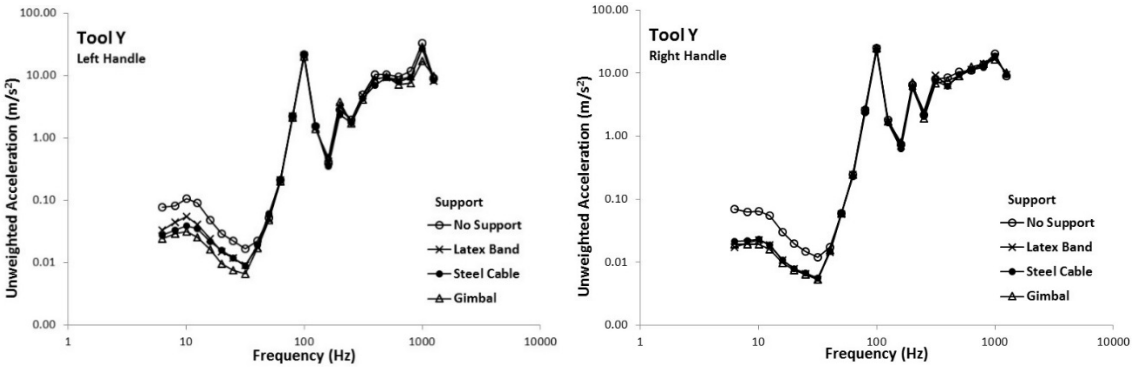

Figure 2. The average left- and right-handle frequency spectra for one of the grinders operated in the four support conditions.

Conclusions

As we observed in our earlier study,[1] the use of a tool suspension system can provide some health benefits by reducing the forces required to lift and maneuver heavy powered hand tools and by decreasing hand-transmitted vibration exposures. However, the suspension techniques used in this preliminary study were not optimized for reducing tool handle vibration; it may be possible to enhance the vibration-reducing capabilities of these systems by adjusting the damping, stiffness, and/or mass properties of the systems.

References

1. McDowell, T.W., et al. *The Effect of a Mechanical Arm System on Portable Grinder Vibration Emissions*. Annals of Occupational Hygiene, 2015. DOI: 10.1093/annhyg/mev084.
2. ISO. (2009). *ISO 28927-1, 2009 -- Hand-held portable power tools -- Test methods for evaluation of vibration emission -- Part 1: Angle and Vertical Grinders*, Geneva, International Organization for Standardization.

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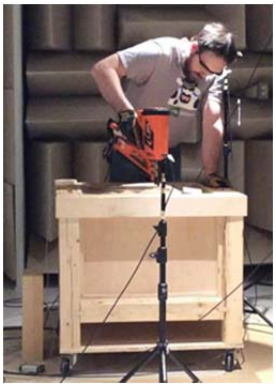
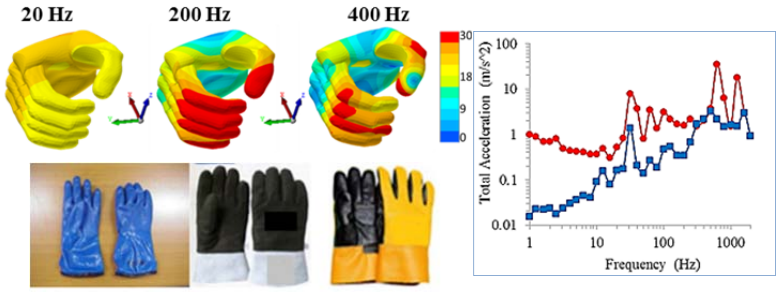
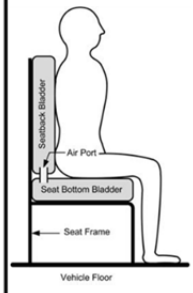
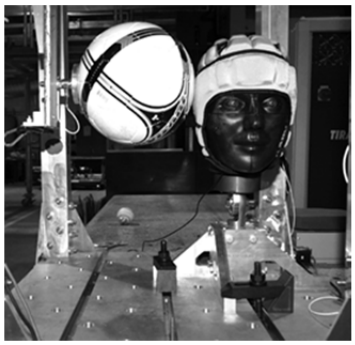
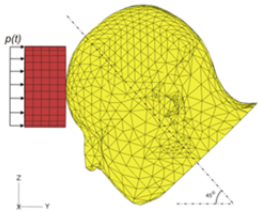


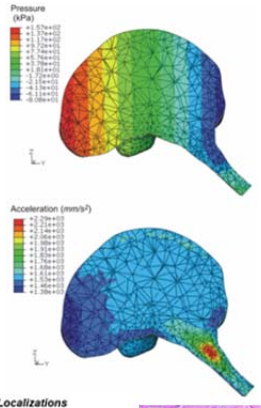


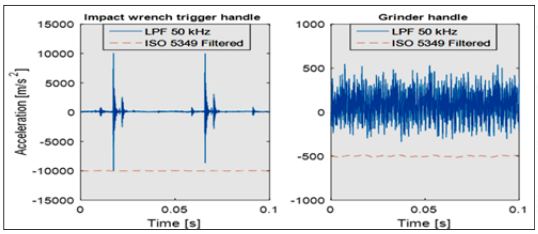
Samples of the Hand Arm, Whole Body and Impact Vibration Research Studies

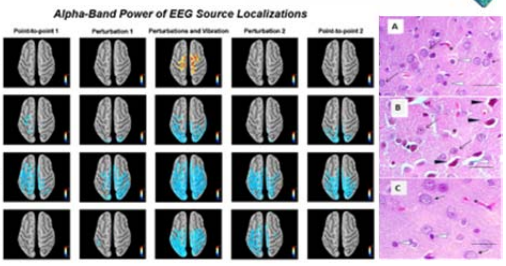












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