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HAND GLOVES AND SEGMENTAL VIBRATION: A REVIEW

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Abstract: Segmental vibration inducing hand held power tools are widely used in most of the industries it is known fact that these vibrations often cause ill effects on health of the operators. Different researches have been conducted across the globe to minimize these ill effects on the health and to improve personal life of the operators. Gloves are often suggested to reduce the vibration transmissions in the hand of operators through palm. Various studies are conducted with some variety of objectives. From these studies one can conclude that the effectiveness of the gloves in reducing vibration hazards depends on various factors such as characteristics of vibration i.e. vibration frequency, direction, magnitude etc., material of gloves and subjects anthropometry i.e. grip strength etc.

Keywords: Hand gloves, Anti-Vibration gloves, Hand arm vibration, Hand held power tools.

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INTRODUCTION

Prolonged occupational exposure to hand transmitted vibration has been associated with development of Hand Arm Vibration Syndrome (HAVS). Some of the measures that can reduce Hand Arm Vibration (HAV) include use of low vibration tool, control of vibration exposure duration and use of anti-vibration gloves. The use of anti-vibration gloves allows diminished cost required to realize the reduction of tool users' HAV exposure and has relatively less negative effect on tool users' labour productivity [1]. Anti-vibration gloves are widely used to help minimize hand–arm vibration exposure [2]. Various studies have been carried out pertaining to segmental vibration and its effects. The studies are also carried out to examine the effect of segmental vibration after using various types of gloves. While the use of gloves often aid in the safety of completing tasks and in some cases can even increase performance, there is most often a trade of between increased safety and performance capability when using gloves. The objectives of one program of research were to examine grasp force at maximal and submaximal exertions, and to address the possibility of relationship tactility and grasp force [3]. Studies were conducted to establish an alternative method for measuring the effects of gloves on the grip strength applied to cylindrical handles and to quantify the strength reduction due to the use of typical anti-vibration (AV) gloves [4]. Study was also conducted with objective to identify major individual factors that are directly associated with the effectiveness of anti-vibration gloves [5]. In a one another research study was carried to enhance the understanding of the mechanisms of the anti-vibration gloves and to evaluate the methods for assessing their vibration isolation effectiveness through developing a mechanical- equivalent model of the glove-hand–arm system [6]. Since powdered latex or vinyl gloves are often used in health care industry as a better protector against latex-induced dermatitis. The research was conducted to evaluate these gloves both with respect to the performance and protection against latex-induced dermatitis. [7]

METHODS:

A method of evaluating the effectiveness of gloves in reducing the hazards of hand-transmitted vibration is proposed The glove isolation effectiveness was calculated from: (a) the measured transmissibility of a glove, (b) the vibration spectrum on the handle of a specific tool (or class of tools), and (c) the frequency weighting indicating the degree to which different frequencies of vibration cause injury. With previously reported tool vibration spectra and glove transmissibilities (from 10–1000 Hz), the method was used to test 10 gloves with 20 different powered tools. With the frequency weighting, the gloves had little effect on the transmission of vibration to the hand from most of the tools. Without the frequency weighting, some gloves showed useful attenuation of the vibration on most powered tools [8]. A methodology to estimate vibration isolation effectiveness of anti-vibration gloves as a function of handle vibration of specific tools is proposed on the basis of frequency response characteristics of the gloves. The handle vibration spectra of six different tools are synthesized in the laboratory and attenuation performances of two different gloves are characterized under tools vibration, and M- and H-spectra defined in ISO-10819 (1996). The vibration characteristics of gloves are measured using three male subjects in the laboratory under different excitation spectra [9]. Different from previous studies that measure the grip force in a specific plane, the alternative method measures the total contact force normal to a cylindrical handle; the total grip strength is defined as the total contact force measured when a subject applies a power grip to the handle with his/her maximum voluntary contraction (MVC) effort. Two instrumented cylindrical handles (30 and 40 mm) were used in this study. Ten subjects participated in the experiment. Four types of AV gloves and two types of non-AV gloves were used in the experiment [4]. In another research series of studies were conducted to examine grasp force at the hand/handle interface under a variety of performance conditions. Three experiments were executed in this study. Experiment 1 was conducted to examine the effect of glove type, pressure differential, and lifted load on grasp force at submaximal exertions. Experiment 2 also examined the effect of glove type and lifted load on submaximal grasp force. In addition, handle size and handle orientation were also examined. Experiment 3 was an examination of the effect of glove type, load lifted, handle size and handle orientation on maximal grasp force [3].

In another study a test methodology using a laser-based vibration sensor is proposed to evaluate the vibration isolation performance of the commercially available anti-vibration and general purpose industrial hand gloves. The vibration transmission characteristics of the human hand-arm system are investigated through measurement of vibration transmitted to the fingers, knuckle and the wrist in the 10-500 Hz frequency range, under different magnitudes of grip forces and vibration excitations. The vibration attenuation performance of nine different gloves is investigated through measurement and analysis of the vibration response of the coupled hand-glove system [10]. In a study conducted with some different objectives, two series of experiments were performed. The first experiment measured the apparent mass of hand–arm system. The second one measured the transmissibility of a typical anti-vibration glove using a palm adapter method recommended in ISO 10819 (International Organisation for Standardization, Geneva, Switzerland, 1996). Six volunteers participated in the experiments. Nine test combinations consisting of three hand–tool coupling actions (grip only, push-only, and combined grip and push) and three coupling forces (50, 75, and 100 N) were used [5]. In a separate study, an alternative method is proposed to assess the vibration isolation effectiveness of these gloves using the biodynamic responses of the bare- and gloved-hand–arm system exposed to vibration. The laboratory experiments were performed with a total of five human subjects using a typical anti-vibration air bladder glove subjected to a broad-band random vibration spectrum in conjunction with a specially designed instrumented handle. The measured data were analyzed to derive the biodynamic responses of the bare as well as gloved human hand–arm system in terms of the apparent mass and the mechanical impedance. The two biodynamic responses were applied to estimate the vibration isolation effectiveness of the glove. The validity of the proposed concept was examined by comparing the estimated vibration transmissibility magnitudes of the glove with those obtained using a palm adapter method [2]. Study was conducted in which A test method based upon total effective acceleration transmissibility (TEAT) is proposed to study the vibration isolation performance of anti-vibration gloves. The vibration transmission characteristics of three different gloves are investigated under predominantly axial vibration using the proposed method and the procedure outlined in ISO-10819 (Mechanical Vibration and Shock—Hand–Arm Vibration—Method for the Measurement and Evaluation of the Vibration Transmissibility of Gloves at the Palm of the Hand, International Standard Organization, Geneva, Switzerland, 1996). The measured data are systematically analyzed to illustrate the measurement and evaluation errors arising from misalignments of the response accelerometer within the palm-held adaptor, unintentional non-axial vibration caused by the vibration exciter and dynamics of the coupled hand–handle system. The degree of adaptor misalignment, estimated from the measured data, was observed to vary from 5.91 to 59.61. Such variations could cause measurement errors in excess of 20%. The vibration transmission characteristics of selected gloves, evaluated using the proposed method, are compared with those derived from the standardized method to demonstrate the effectiveness of the TEAT approach [11]. In different research, model is developed based on the measured driving-point mechanical impedances distributed at the fingers and the palm of the hand with and without a glove. In this study six subjects participated in the experiments with two types of anti-vibration gloves (air-bladder glove and gel-filled glove) for measuring the required impedance data. The proposed model is applied to predict the effectiveness of the glove in terms of vibration transmitted to the fingers-glove and palm-glove interfaces, the finger bones, and the wrist [6]. Study was conducted and the mean vibration transmissibility values were measured for cotton work gloves commonly used in vibration-generating workplaces to evaluate the vibration isolating performance of cotton work gloves. The mean vibration transmissibility values of work cotton gloves were compared with those of four types of anti-vibration gloves measured in the same way. All the measurements were performed based on the newly issued JIS T8114 that is identical to ISO10819. Also, linear transmissibility values were calculated from the measured data [1]. In one study authors evaluated anti-vibration glove test protocols associated with the revision of ISO 10819. In this study glove vibration transmissibility tests were conducted using a constant velocity vibration input with a value of 0.01 m/s in each frequency third octave frequency band from 16-1600 Hz (F spectrum). Glove vibration transmissibility results obtained using the M (16-400Hz) and H (100-1600 Hz) spectra specified in ISO 10819: 1996 were compared to similar results using the constant velocity spectrum. The results obtained from the constant velocity spectrum, when divided into M and H frequency ranges were nearly same as those obtained from the ISO 10819 M and H spectra. [12] Twenty-five male students from the College of Engineering & Technology and 25 female students from the College of Dentistry at the University of Nebraska participated in the experiment. Two types of gloves (latex and vinyl) were combined with powdered and non-powdered conditions. A number of performance measures were gathered. These included strength, dexterity, tactility, and functional tests. The data of glove properties was collected from a glove manufacturer. [7]

RESULTS AND DISCUSSIONS

Different results were drawn from studies which are discussed above. The frequency weighting for hand-transmitted vibration advocated in British standard 6842 (1987) and international standard 5349 (1986) greatly influences the apparent isolation effectiveness of gloves [8]. The results suggest that tool-specific vibration isolation performance of a glove cannot be derived from the standardized M- and H-spectra. Frequency responses of the gloves are thus characterized under broad-band vibration excitations of two different magnitudes, and grip and feed forces recommended in ISO-10819. The results suggest that frequency response characteristics of gloves are relatively insensitive to magnitude of vibration but strongly dependent upon visco-elastic properties of the glove materials. The mean measured frequency response characteristics are then applied to derive an estimate of tool-specific isolation effectiveness of the gloves. The estimated acceleration transmissibility characteristics of gloves are compared with the mean measured responses to demonstrate validity of the proposed methodology [9]. Compared with bare-handed trials, each of the four anti-vibration gloves reduced the grip strength by more than 29%, regardless of handle size. One of the non-AV gloves also largely reduced the grip strength (25%) whereas the grip strength reduction of the other one was less than 10%. The gloves also influenced the grip force distribution pattern around the circumference of the cylindrical handles. The results of this study suggest that the thickness of a glove is one of the major factors associated with these effects [4]. Findings of another study indicated that grasp force was effected by frictional and load tactile feedback. Consistent with published evidence, there was a strong glove effect at maximal exertions.

However, the glove effect was marginal at submaximal exertions. This suggests that the neuro-muscular mechanisms utilized during maximal exertions are differentially applied and/or different from those used during submaximal or `just holding types of exertion [3]. Study in which the vibration response characteristics are utilized to propose two- and three-degrees-of-freedom (DOF) lumped parameter linear models of the hand and hand-glove systems, respectively. A comparison of the vibration transmissibility response of the proposed models with the measured data revealed reasonable correlation in the frequency range of interest. The results of the study further revealed that the gloves do not yield effective attenuation of vibration caused by the hand-held power tools [10]. Study found that the vibration transmissibility of the glove was reliably correlated with the apparent mass in the frequency range of 40–200 Hz; and that the glove became more effective when the apparent mass was increased [5]. Effective stiffness of the hand–arm system at frequencies from 63 to 100 Hz as the key factor that influenced the biodynamic response and the glove transmissibility measured at the palm of the hand. Although not statistically significant, there was a trend that the anti-vibration glove was less effective in the middle frequency range (50–100 Hz) for people with larger hand sizes [5]. The comparison of the results suggests that the proposed method offers a good alternative for estimating glove vibration transmissibility. The measured data and the proposed method based upon the biodynamic responses were further used to investigate the effect of the palm adapter on the vibration transmissibility of the glove. The results suggest that the presence of the palm adapter between the subject's palm and the glove may not alter the basic trends in the transmissibility response, but it would affect the transmissibility magnitudes in the middle- and high-frequency ranges. A distinct advantage of the proposed method is that it eliminates the use of an adapter in assessing the vibration isolation effectiveness of the gloves [2]. The results show that the gloves could provide some attenuation of the palm-transmitted vibration at frequencies above the fundamental resonant frequency of the gloved hand–arm system, but only little reduction in the finger vibration below the dominant finger resonant frequency. The present standardized methodology based upon the transmissibility measurement at the palm alone would thus be inappropriate for characterizing the overall reduction of the vibration exposure by a glove. Moreover, the palm adapter could introduce some measurement errors because of its mass and misalignment effects and its interference with the glove- palm coupling relationship. Therefore, the standardized method may only be used for general screening tests. On the basis of the model results, several potential improvements in the current standardized methodologies for evaluations of gloves and glove material are proposed and discussed. The proposed model may also serve as a useful tool for further developments of anti-vibration gloves and other anti-vibration devices [6]. Cotton work glove samples did not satisfy the requirements specified in JIS T8114. All the test samples showed mean vibration transmissibility values of more than 1.0 for spectra M and H. In contrast, all the anti-vibration gloves tested in this study satisfied the JIS T8114 requirements. The linear transmissibility values of cotton work gloves were consistently higher than those of anti-vibration gloves for spectrum H. The linear transmissibility values of cotton work gloves were steady at about 0.9 up to 200 Hz, then increased with vibration frequency to about 1.0 at 400 Hz. In contrast, the linear transmissibility values of anti-vibration gloves increased with frequency to 1.0 at 30 Hz and then decreased with small peaks at 100 Hz and 300 Hz. Our results suggest that cotton work gloves do not show enough vibration-isolating performance [1]. Results of another study suggest use of powdered latex gloves for non-affected population, and use of non-powdered vinyl gloves for sensitized population. Objectives with respect to protection against latex-induced allergens could not be achieved due to operational difficulties. Notwithstanding these, the performance results have been combined with available literature from the medical field, and recommendations made [7].

CONCLUSIONS

It is concluded that the isolation effectiveness of gloves for selected tools can be effectively predicted using the proposed methodology. The deviations between the predicted and measured transmissibility values are within 8% for majority of the glove–spectra combinations, well within the intra- and inter-subject variabilities reported in different studies.[9] Knowledge of the effects of gloves on grip strength can help workers, managers, and safety professionals make informed decisions about glove selection and use in the workplace. This knowledge may also lead to work glove improvements [4]. The TEAT method, based upon vector sums of both the source and response accelerations, can effectively account for the majority of the measurement errors, and yield more repeatable and reliable assessments of gloves. [11] Therefore, attention should be paid to encourage the widespread use of anti-vibration gloves in place of cotton work gloves to reduce exposure to hand-arm vibration. [1]

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