Chapter 1

Introduction

1.1 Introduction

Whole-body vibration (WBV) is a health hazard faced by heavy earth moving machine operators in many industries, including mining, agriculture, forestry and manufacturing [1][2]. In mining industries, the dumper, drill, and shovel operators are the worst sufferers from WBV syndrome [3]. Moreover, WBV is a common experience for people on many occasions in their lives while travelling in a car, bus, or train, or while riding a bicycle or a motorcycle. When a person is in contact with a shaking/vibrating surface, he experiences vibration over his whole body parts (though remote from exposure site). This is called WBV [4]. In many work environments, people are primarily exposed to vibration while seated and are exposed to a wide range of vibration magnitudes, waveforms, and durations, which may be continuous or transient. Depending on the magnitude and duration of exposure, WBV impacts the health and safety of human being and specifically it affects the musculoskeletal system. The health hazards are classified into three categories depending on the magnitude of exposure and its duration, as prescribed in ISO 2631-1: 1997 guidelines. Three categories of health guidance caution zone (HGCZ) in ISO 2631-1:1997 refers to: (i) no health risk zone, (ii) potential health risk zone and (iii) likely health risk is likely zone.

Moreover, long-term exposure to WBV can lead to musculoskeletal disorders (MSDs), as reported by many researchers. A high prevalence of MSDs, mainly in upper limbs and lower back [5], is found among off-road vehicle operators in mining [6], agriculture [7] and construction activities [8]. Epidemiological studies on WBV demonstrate increased risk of lower back pain, sciatic pain, and degenerative changes in the spinal system, including lumbar intervertebral disc disorders [9]. In addition, motion sickness, headache, impotence, kidney disorders, chest and abdominal pain, increased heart rate, high blood pressure, blurred vision, and kidney disorders due to WBV are also reported in past studies. Other than the health impacts of WBV, it also affects the work efficiency of the workers at the workplaces.

Exposure to WBV is inherently associated with various mining operations. These vibration exposures are caused by acceleration produced by heavy earth moving machinery (HEMM) during their operation. Prolonged exposure to WBV can have a detrimental effect on the operator's health. This exposure becomes more important when the magnitude of vibration is high. Coupled with long, frequent & regular exposure, and also containing frequent shock and impact components. High levels of WBV are also reported from various mining equipment operators such as dumpers [10], [11]; drill [12], shovel[12], LHD [13], [14], and dozer [15], [16].

Research works on WBV and its impact depend on multiple confounding factors, including the demography and anthropometry of the operator, duration of exposure, ergonomics of the seat design, and the work environmental factors. Although many factors have been discussed in the literature, the reason of WBV and its health effects are still not explored fully. Therefore, there is a need to investigate the effect of WBV

on HEMM operators in mines and to understand the correlations that exist among its confounding factors.

1.2 Scope of Research

WBV is multidisciplinary in nature, and the role of contributing factors in the causation of the injury/disease are still unexplored, though a deeper understanding of the factors has been explained in many research works [4]. Therefore, the scope of the present research work has been limited to the measurement of vibration following the guidelines of ISO 2631-1:1997, supplemented by a questionnaire survey of a group of HEMM operators in coal mines. In order to understand the role of contributing factors on the causation of MSDs, a group of workers who are not exposed to vibration has also been considered through a questionnaire survey. The questionnaire incorporates the survey of personal information of the workers and the discomfort/pain that the operators/workers are facing for the last six months.

1.3 Objectives of the Research

To fulfill the scope of the work, the following objectives are defined.

(i). Investigation of WBV exposure of various HEMM operators in opencast coal mines in terms of

- Measurement of WBV exposure of operators
- Assessment of health risks of operators using a questionnaire survey

(ii). Comparison of WBV exposure of HEMM operators with ISO 2631-1:1997 guidelines.

(iii). Discomfort survey of HEMM operators exposed to WBV and correlating them with the WBV magnitude and its various contributing parameters.

(iv). Assessment of musculoskeletal disorders and contributing factors of WBV to investigate the relative risk using case–control study.

1.4 Organization of the Thesis

Chapter 2 presents literature review related to WBV its measurement and calculation procedure, its effects, and mechanical vibration analysis, sensors and transducers used. Chapter 3 discusses the methodology that describes the measurement of the WBV exposure, collection of data regarding individual subjects, field visit, and statistical inferences. Chapter 4 deals with the case study mines and field visits for data collection and vibration measurement. Chapter 5 presents WBV measurement of the HEMM operators in the field using Human Vibration Analyzer. Chapter 6 discusses the discomfort survey and calculation of different types of discomfort indices. Chapter 7 describes the study design of the case–control analysis and the logistic model. Chapter 8 presents the conclusion part of the research work along with some suggestions for future work in this line.