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ScienceDirect

Procedia Engineering 112 (2015) 379 – 384

Procedia Engineering

www.elsevier.com/locate/procedia

7th Asia-Pacific Congress on Sports Technology, APCST 2015

Development of new simulator generating high frequency component of ski board vibrations in actual skiing

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Abstract

The purposes of this study are to develop the new simulator generating high frequency component of a ski board vibration in skiing and to investigate the key factor to influence the ski sliding performance of the ski board. Using this simulator, a coefficient of kinetic friction (μ_k) between the snow and the ski board with the vibration of 0 Hz (no vibration), 263 Hz and 361 Hz were investigated. Furthermore, a field experiment for verifying these experimental results using a simulator was carried out in a ski area. From these experiments, a high vibration frequency of the ranges from almost 200 Hz to 400 Hz occurred on a ski board has been thought to be key factor to influence the sliding performance of the ski board.

Peer-review under responsibility of the the School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University

Keywords: Simulator; high frequency component; ski board vibration; coefficient of kinetic friction

1. Introduction

The mechanism of ski sliding still has not been completely clarified. Some hypotheses have been set up. One hypothesis is related to pressure; the melted snow between the bottom surface of the ski and snow surface is transformed by the pressure exerted by the ski, becoming a lubricant and thus decreasing the dynamic friction force or the coefficient of kinetic friction [1]. This hypothesis, however, has been proven negative because the square of a

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Peer-review under responsibility of the the School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University
doi:10.1016/j.proeng.2015.07.211

ski bottom surface was too large to be melted the snow surface by a pressure. Another hypothesis is related to friction; melted snow between the ski bottom surface and snow surface becomes a lubricant and decreases the dynamic friction force or coefficient of kinetic friction due to the dynamic friction force involved in skiing [1]. The dynamic friction force, however, has been implicated as the resistance force in ski-skier's system motion equation as follows;

$$M\frac{\Delta v}{\Delta t} = Mg\sin\theta - Mg\mu_k\cos\theta - Dg(\frac{\Delta s}{\Delta t})^2 - R \tag{1}$$

where Mg*sinθ is the driving force, mg*$\mu_k$cosθ is the snow resistance force, Dg is the air drag force and R is the shoveling resistance force. Furthermore, no one has yet discovered whether melted snow truly acts as a lubricant between the bottom surface of the ski and the snow surface. On the other hand, a new viewpoint has been proposed regarding the adhesion mechanism between the bottom surface of the ski and the snow surface.

Concerning to ski sliding, Tanahashi [1] reported that a vibration frequency of over 200 Hz on a ski board when an expert was skiing was stronger than that when a beginner was skiing. Furthermore, Shionoya [5] developed a simulator generating ski board vibrations in actual skiing and reported that the velocity and acceleration of ski board with a vibration of more than 200 Hz were higher than without vibration and the coefficient of kinetic friction (μ_k) with vibration was lower than without vibration. From these previous studies, a vibration frequency of more than 200 Hz or the farther high frequency, of which is more than 300 Hz, on a ski board while skiing has been thought to be one key factor to influence the sliding performance of a ski board.

The purposes of this study are to develop the new simulator generating high frequency component of a ski board vibration in skiing and to investigate the key factor to influence the sliding performance of a ski board.

Nomenclature

μ_k	coefficient of kinetic friction
F	dynamic friction force
M	weight of a mass snow (snow pack)
G	acceleration of gravity

2. Development of new simulator generating high frequency component of ski board vibrations in skiing

Figure 1 shows an outline of an new simulator generating a high frequency component of ski board vibrations. In the simulator, the surface below the ski is assumed to be a snow slope and a mass of snow (snow pack), and we assume a skier slides on this bottom surface [5]. A digital force gauge is set on the snow pack and connected to the traction device by a wire. The snow pack with a force gauge is pulled and slides on the surface formed by the bottom of the ski at uniform velocity by this traction device. The velocity of a snow pack pulled can be changed between 5cm/s and 100cm/s. A dynamic friction force (F) is detected by a digital force gauge as the snow pack is pulled on the bottom surface. The detected force, which is saved in USB memory stick once, is transferred to a personal computer and transformed by an A/D converter. The motion of equation of a snow pack is

$$F = \mu_k Mg \tag{2}$$

where M is the weight of snow pack, g is the acceleration of gravity, F is the force of dynamic friction force and μ_k is a coefficient of kinetic friction, calculated by the following formula (Figure 2);

$$\mu_k = \frac{F}{Mg} \tag{3}$$