



Tuned vibration absorber for suppression of hand-arm vibration in electric grass trimmer

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ABSTRACT

Prolonged use of electric grass trimmer exposes the user to the risk of hand-arm vibration syndrome. A simple approach for the suppression of hand-arm vibration in electric grass trimmer is presented. The proposed system is a tuned vibration absorber (TVA). Modal analysis and operating deflection shape analysis of the electric grass trimmer were carried out and a TVA was designed and fabricated for testing. The results indicated that minimum vibration level was related to the position of the TVA on the shaft of electric grass trimmer. The TVA was found to have best performance with 95% reduction on the acceleration level at position 0.025L. The results from modal analysis and operating deflection shape revealed that the presence of TVA has successfully reduced the large deformations of the handle where the node was shifted nearer to the handle location. The effect of TVA was also evaluated during field test involving grass trimming operation and subjective rating. The results indicated that average reduction of frequency-weighted rms acceleration in the Z_h -axis was 84% and 72% in X_h -axis for the cutting operation. For the no cutting operation, the reduction is 82% in Z_h -axis and 67% in X_h -axis. The presence of TVA in the electric grass trimmer has amplified the vibration level in Y_h -axis by 19% (no cutting) and 21% (cutting). From the field test, subjective rating of vibration perception consistently rate better for controlled electric grass trimmer.

Relevance to industry: The tuned vibration absorber when installed to the electric grass trimmer attenuated the vibration total value by 67%. This significantly reduces the risk of hand-arm vibration syndrome.

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1. Introduction

Grass trimming is usually carried out with the use of petrol engine or electric motor powered trimmer which uses a rotating nylon string that cut the grass. The use of petrol engine is subjected to emission regulation which limits their application. The US Environmental Protection Agency (2010) has adopted new regulations for small engines (operate at or below 19 kW) that are widely used in lawn and garden area. Electric models produce no emissions at the point of use. This factor favours the application of electric grass trimmer for maintenance of grass compound in places where emission is regulated. The electric grass trimmer usually employs an AC electric motor of 400 W with the plastic rotating head coupled directly to the motor. A single nylon string is attached to the rotating head. The single string construction of the electric grass trimmer made it a rotationally unbalanced which resulted in

high level of vibration. Under this condition the user is exposed to hand-arm vibration (HAV). Extensive exposure of HAV can lead to a series of vibration induced disorder in the vascular and nonvascular structures in human hand-arm. These disorders are referred to hand-arm vibration syndrome (HAVS) (Mansfield, 2005).

HAVS is classified as an industrial disease and has been affecting innumerable workers. Loriga in 1911 is the first to document the relationship between the exposure of HAV and HAVS (Bylund, 2004). Great efforts have been made by researchers in order to reduce vibration of hand tools and its effect. These included isolation of the hand from the vibrating handle with the use of anti-vibration gloves (Brown, 1990; Muralidhar et al., 1999; Voss, 1996). The effect of anti-vibration gloves to the human–tools interface has been extensively studied, such as the investigation of the vibration isolation characteristic for a gloved hand using a laser-based vibration sensor (Gurram et al., 1994); development of a more reliable method for assessment of effectiveness of anti-vibration glove (Dong et al., 2003); evaluation of the effect of wearing anti-vibration gloves on the grip strength applied to cylindrical handles (Wimer et al., 2010). However, different hand

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