윤활유 및 마찰 감소재를 이용한 산악트램 스퀼소음 저감 기술 동향

Technical Review on The Curve Squeal Noise Reduction Using Lubricant and Friction Modifiers for Mountain Trams

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Abstract: Curve squeal is an intense tonal noise that occurs when a train travels through a narrow curve. This article discusses the curve squeal noise reduction possibilities in the mountain trams using lubricant and friction modifiers. In this context, the curve squeal mechanism is described. The highlights are the lubrication and friction modifiers from their practical implementation perspective and main review results concerning the reduction of curve squeal noise in some countries. The conclusion states that both lubrication and friction modifiers methods are appropriate techniques for curve squeal noise reduction even though water spray lubrication cannot be used during winter. In the future study, we recommend that two mitigation methods should be combined since there is no study on combination of measures.

Key words: Wheel squeal, Lubricant, Friction modifier, Mountain tram.

1. Introduction

Noise is the problem of the railway that has continued and curve squeal noise is one of the noise problems [1]. Especially for mountain trams, the curve squeal noise is the main concern that affects the comfortability of the passengers and natural habitat because it runs the sharp curve with approximately 10 m radius. Therefore, to find the method to reduce the squeal noise, many studies on reducing noise have been reviewed.

2. Curve Squeal Mechanism

Rudd [2] mentioned three possible excitation mechanisms, each owing to stick-slip behavior in the contact region: first, wheel flange rubbing against the rail; second, lateral creep of the wheels on top of rail; third, longitudinal slip between inner and outer wheels on a solid axle.

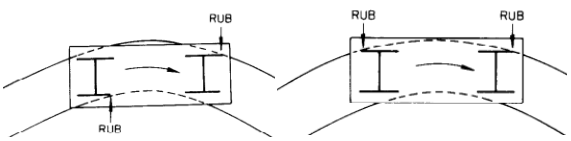

Fig. 1 Truck in a curve: low speed (left) and high speed (right) [2].

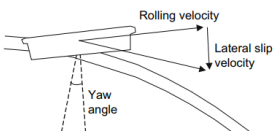

Fig. 2 Generation of lateral creepage by non-zero yaw angle [3].

Fig. 1, The back wheelset and the leading wheelset are in the flange contact with the inner rail and outer rail, respectively, at low speed. At high speed, the back wheelset moves outwards [3].

The angle of attack (AoA) between the leading wheelset and the rail is thus greater at low speed and sharp curve. Since the front wheelset has a high level of AoA, it cannot move straight forward but it rolls

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around the curve by the flange instead due to it being constrained, and it produces a relative lateral velocity between the rail and wheel, as illustrated in **Fig. 2**.

3. Lubrication and Friction Modifiers

Friction modifier acts by lowering the falling friction characteristic without reducing friction level so much [3]. Top-of-Rail friction modifier can be applied in two ways such as wayside and on-board applicators as shown in **Fig.3** [7].

Fig.3 TORFM application systems; (a): wayside; (b) on-board [7].

Friction modifiers are available as solid track, it is able to apply on the vehicle to rub the wheel tread and/or flange. Recently, they are also available as water-based liquids which can be applied either from the vehicle using a spray system or to the track at entrance to a curve [3].

Eadie et al [4] reported a field test using Top-of-Rail friction modifiers for 5 vehicle systems, which successfully reduced curve noise. Additionally, Eadie et al [5] used a water-based liquid friction modifier to the top of rail in 3 different test sites for trams, the results revealed that this method can be used to mitigate the squeal noise.

Lubrication using either water or grease works by reducing the friction coefficient and thereby also the difference between sliding and static friction coefficients [3]. Maintaining low gauge corner and gauge face levels can reduce curve squeal noise as well [7].

At some places, wheel squeal is greatly reduced when raining. Nelson [6] stated the effect of water spray lubrication over the petroleum lubrication on curve squeal. However, the water spray method is not able to be used during the winter periods, thus the petroleum will be compensated even if it pollutes soil more.

Oertli [1] also reported the effect of mist (water) spray system on curve squeal, and he also introduced the effect of friction modifier on curve squeal for passenger coaches in the UK.

Both gauge face lubrication and Top-of-Rail friction modifier function by introducing a third layer between the rail and steel wheels. Liquid gauge face lubricants are commonly used as petroleum and water-based preferred by Top-of-Rail friction modifier [7].

4. Conclusion and Suggestion

The curve squeal noise reduction using lubricant and friction modifiers were reviewed. These two methods are effective to reduce curve squeal noise for mountain trams. It has been difficult to compare these methods due to varying measurement setups and analyses.

For future research, we suggest combining measures together since there are no investigations on a mix of different mitigation methods, to date.

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