# Brake insulator analysis in reducing internal brake squeal noise

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**ABSTRACT** – Brake functions when two different materials are in contact to reduce a motion. Due to surface irregularity, this contact at high revolution and contact force produce irritating noise called brake squeal noise. This paper presents the study of introducing brake insulator into the brake assembly in order to reduce the noise. Different configurations of insulators are used in the Finite Element Analysis (FEA). The squeal is shown by positive real part of the baseline graph. The accompanied slip rate in the baseline model of the insulator increases the brake squeal noise significantly.

## 1. INTRODUCTION

There are few terminologies for brake noise such as squeal, groan, chatter, judder, moan, hum and squeak that can be found in literature. However, the terminology that often be used is squeal. The phenomenon of squeal is probably the most common, disturbing to users and environment, and its cost the manufacturer in term of warranty. There are no precise definitions for brake squeal, but it is frequently agreed that squeal occurred at frequency above 1000 Hz [1,2]. Drum brake (Figure 1) produces significant amount of noise compared to disc brake. Motorcycle brake which is using the drum brake type is used for this study.

Brake is one of the most important things that need to be considered when producing a vehicle. The squealing sound that produced from the brake not only contributed to the noise pollution, but also make the users are not comfortably used the vehicle. They thought that the brake might be broken down and the vehicle are not safely be used which will lead them to claim a warranty from the company that produced the vehicle.

## 2. METHODOLOGY

There are two stages have been followed to achieve the objective, which are: i) develop the finite element model of the rear drum brake system that based on the real system components, ii) run the stability analysis with and without insulator to analyze the effectiveness of the insulator in squeal suppression. The stress analysis performed [3-6] using ABAQUS software through complex eigenvalue analysis (CEA), the positive real part of the (CEA) indicate unstable frequency (the propensity of squeal occurrence). Different types of material for the insulators (Figure 1) have been proposed to reduce the squeal generation and it was found that the method is efficient to suppress the squeal occurred but it does not fully eliminate the squeal generated.

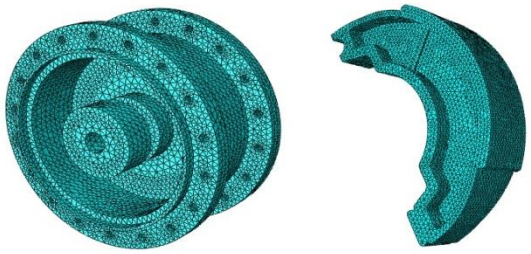

Figure 1 Drum brake and shoe insulator.

There are a few approaches used in predicting the probability of the squeal occurrence which are theoretical, experimental and Finite Element (FE) approaches. Besides, there are several methods also proposed to suppress or reduce the squeal occurrence which are; structural modifications, active control and adding damper. From the three methods, adding damper is the most efficient method and it may be applied by changing the material with high damping material or by adding insulator to the pad or shoe, which depend on what type of brake that will be used (Figure 2 and Table 1). Finite element (FE) method of drum brake system for motorcycle will be used to predict the squeal occurrence from 1 kHz until 10 kHz and insulator will be used to reduce the noise.

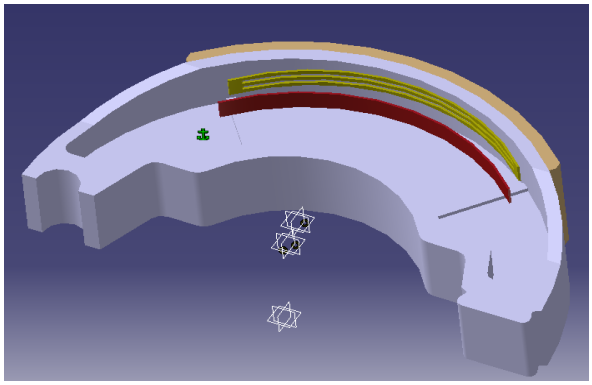

Figure 2 Insulator configuration.

Table 1 Sample insulator configuration.

| Sample | Configuration |
|---|---|
| 1 | Frame rubber 0.5 mm thickness & steel plate 0.5 mm thickness |
| 2 | Frame ABS 0.5 mm thickness & steel plate 0.5 mm thickness |
| 3 | Rubber plate 0.5 mm thickness & aluminum plate 0.5 mm thickness. |
| 4 | Frame ABS 0.5 mm thickness & aluminum plate 0.5 mm thickness |
| 5 | Rubber plate 0.5 mm thickness & composite plate 0.5 mm thickness |
| 6 | Frame ABS 0.5 mm thickness & composite plate 0.5 mm thickness |

## 3. RESULTS AND DISCUSSION

Figure 3 shows the predicted result of the squeal occurrence of the FE model of the drum brake system. The result of the project will be compared between the baseline models which have a static coefficient of friction without slip rate and another one is baseline models with the presence of slip rate. The complex eigenvalue analysis performed by setting a set of boundary condition, where the frequency of interest is between 1 to 10 kHz, the rotational speed of drum is set to be 40 rad/s, the displacement of the cam for brake applying is set to be 4 mm and the coefficient of friction, $\mu$ is varied from 0.3 to 0.5. It is clearly can be seen that baseline model without slip rate that contains coefficient of friction, $\mu$=0.30 have no squeal generation. However, the squeal is detected when the coefficient of friction, $\mu$ is 0.4 and 0.5. There is one squeal detected for $\mu$=0.4 at frequency 5677.7 Hz and $\mu$=0.5 at frequency 5659.9 Hz. Previously in literature review, it is stated that this phenomenon occurred is due to the magnitude of stiffness matrix with increasing friction coefficient. The addition of the friction coupling forces at the friction interface result in the stiffness matrix for the system containing unsymmetrical off-diagonal coupling term. From this stability point of view, this coupling is considered as the reason of brake squeal occurred.

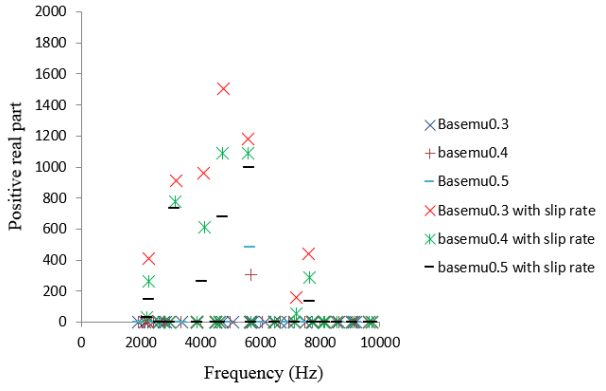


Figure 3 Baseline graph results at different coefficient of friction.

## 4. CONCLUSION

Complex eigenvalue analysis is the tool that has been used successfully to predict the squeal noise in a drum brake system. Using complex eigenvalue analysis may help in reducing the cost of the experimental tests and shorten the time of the experimental test by just doing analysis, and also it will provide a clear vision about which design could be more successful. Based from the result in previous section, it is clearly can be seen that brake insulator could help in reducing brake squeal. Although all the pair of materials has a potential to reduce the brake squeal, however, the pairs of iron material with rubber show more detail and precise result compare to the pairs of iron material with ABS.

## ACKNOWLEDGEMENT

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