Disc Brake Squeal-A Review

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Abstract: **In automotive industry, Brake squeal is major problem and lot of research has been carried out to minimise this problem. The brake noise is considered as discomfort to discomfort by the passenger and is a failure state in the eye of the manufacturer. The audible noise generated can be related to physical vibrations occurring in the system which is termed as stick-slip effect. Thus understanding this class of vibration, which is generally friction induced by having the friction coefficient varying with relative speed, is necessary to eliminate brake noise.**

Keywords: **Brake Squeal, stick-slip effect, Friction induced Vibration.**

I. LITERATURE REVIEW

Sujay Hegde and B S Suresh (2015) [1] studied the oscillation between the brake pad and disc using a simple 1-DOF model. In thus study, stick-slip phenomenon is simulated and studied by using complex non-linear friction laws and contacts between a mass and moving belt. Also, a parametric study is conducted to study the effect of mass, spring and friction parameters on the stick-slip effect. A transient multi-body simulation is conducted on a simple 1 DOF model to simulate and study the stick-slip phenomenon, which includes non-linear friction law and multi-point contacts using LMS Virtual Lab.

N.M.Kinkaid, O.M.O'Reilly, and P.Papadopoulos (2002) [2] provides a comprehensive review and bibliography of works on disc brake squeal. In an effort to make this review accessible to a large audience, background sections on vibrations, contact and disc brake systems are also included. They discussed centre on a linear analysis to predict the onset of instability. As noted earlier, several researchers have correlated this instability to the occurrence of squeal. However, the real issue is what happens after instability has occurred. It is well known that to address this issue one needs a non-linear model. This issue has not been significantly pursued in the disc brake squeal literature. One of the reasons for this is that a nonlinear analysis of a large degree-of-freedom model is a formidable task.

V. N. Pilipchuk and R. A. lbrahim (1990)[3] introduces the analytical modeling and dynamic characteristics of disc brake systems under equal contact loads on both sides of the disc. The friction force acting on the pad is assumed to be concentrated along its trailing edge due to the moment arising from the friction force, and thus results in a redistribution of normal forces. In view of equal contact forces, the disc will not experience transverse motion but only tangential and radial vibrations. The only nonlinearity involved in the model arises mainly from contact forces. The dependence of the friction coefficient between the pad and disc is smoothed at zero relative velocity to avoid the problem of differential inclusion. Some preliminary numerical results of the disc and pad are obtained. The results exhibit the occurrence of stick-slip with a relatively small high frequency component during the sliding regime. The later component is mainly due to higher elastic in-plane modes of the disc, whereas the stick-slip component is a global disc pad motion involving the lowest pad mode.

Choe-Yung Teoh, Zaidi Mohd Ripin and Muhammad Najib Abdul Hamid(2012)[4] introduces the Drum brake squeal is modelled as friction excited vibration based on the binary flutter mechanism which requires the convergence of two modes experimentally identified using Modal Assurance Criterion. Transient analysis is carried out to determine the brake drum response under braking condition and the model produces squeal mode at 2026 Hz comparable to the measured squeal frequency of 1950 Hz. There are limited combinations of the location of centre of pressure of the shoes that cause squeal. The amplitude of the limit cycle of the drum brake squeal can be reduced by increasing damping, mode frequency separation and reducing the contact stiffness.

C.W. Park, M.W. Shin, H. Jang(2013)[5] studied The effect of brake disc corrosion on friction-induced stick-slip was studied to find the possible causes of friction instability in humid conditions. The friction and wear characteristics of gray iron discs and a commercial friction material were examined using a 1/5 scale dynamometer. Use of the corroded discs resulted in a higher friction coefficient, and larger oscillation amplitude of the brake torque .Disc corrosion increased the critical velocity showing transition from steady sliding to stick-slip. This suggests a rapid increase of the initial static friction coefficient as a function of dwell time in a humid condition, which is supported by the increased hydrophilicity of the friction films.

A. Belhocine, A.R. Abu Bakar, M. Bouchetara (2014[6] They investigate and analyse the temperature distribution of rotor disc during braking operation using ANSYS Multiphysics. The work uses the finite element analysis techniques to predict the temperature distribution on the full and ventilated brake disc and to identify the critical temperature of the rotor by holding account certain parameters such as; the material used, the geometric design of the disc and the mode of braking. The analysis also gives us, the heat flux distribution for the two discs.

M. Triches Jr, S. N. Y. Gerges and R. Jordan(2004)[7] The addition of a constrained layer material to brake pads is commonly utilized as a means of introducing additional damping to the brake system. Additional damping is one way to reduce vibration at resonance, and hence, squeal noise. This work demonstrates the use of modal analysis techniques to select brake dampers for reducing braking squeal. The proposed methodology reduces significantly the insulator selection time and allows an optimized use of the brake dynamometer to validate selected insulators.

Igor Iroz, Peter Eberhard (2015) [8] Explained By means of elastic multibody dynamics and the presented contact modeling, computationally efficient time integrations are performed and the amplitudes of the oscillations for a number of operational parameters are predicted. This way, conclusions on the stability of the system are drawn and a new criterion for quantifying the squeal propensity of a system affected by friction-induced vibrations is proposed.

Amr M. M. Rabia, Nouby M. Ghazaly, M. M. M. Salem, Ali M. Abd-El-Tawwab (2013)[9] studied a detailed experimental study of the disc brake vibration is performed on a simplified brake dynamometer. The preliminary brake dynamometer consists of three subsystems, namely driving unit, braking unit and measurement facilities. It is also found that the vibration level decreases with the increase of sliding speed. Moreover, it is observed that the vibration level decreases with the increases of applied pressure.

K. Shin, m. J. Brennan, j.-e. Oh, c. J. Harris(2011)[10] a two-degree-of-freedom model is adopted where the disc and the pad are modelled as single modes connected bya sliding friction interface. Using this model, the interaction between the pad and the disc is investigated. Stability analysis is performed to show under what parametric conditions the system becomes unstable, assuming that the existence of a limit cycle represents the noisy state of the disc brake system. The results of this analysis show that the damping of the disc is as important as that of the pad. Non-linear analysis is also performed to demonstrate various limit cycles in the phase space. The results show that the addition of damping to either the disc or the pad alone may make the system more unstable, and hence noisy.

Shahabaj Bagwan and Prof.S.V.Shelge (2015) [11] In this paper various parameters influencing disc brake squeal are studied from literatures. Various parameters are braking pressure, rotational velocity, coefficient of friction, damping, modifications in disc and pad. During braking operation braking pressure, rotational velocity are not in control. Decrease in coefficient of friction reduces the brake squeal, but it is not applicable because it lowers the braking performance. Damping shims to reduce squeal increases the cost of damping material. So best way to reduce disc brake squeal is structural modification in disc brake assembly.

Toru Matsushima, Kazuhiro Izui, and Shinji Nishiwaki (2011)[12] represent an optimal design method for disc brake systems that specifically aims to reduce brake squeal by appropriately modifying the shapes of brake system components to obtain designs that are robust against changes in the pressure distribution along the contact surfaces. First, a simplified analysis model is constructed in which a pressure distribution parameter is introduced, and the relationships between the occurrence of brake squeal and the geometry and characteristics of various components are clarified, using the proposed simplified analysis model.

Abd Rahim Abu-Bakar,Huajiang Ouyang(2008)[13] Presented recent research into car disc brake squeal conducted at the University of Liverpool. The detailed and refined finite element model of a real disc brake considers the surface roughness of brake pads and allows the investigation into the contact pressure distribution affected by the surface roughness and wear. It also includes transient analysis of heat transfer and its influence on the contact pressure distribution. Finally transient analysis of the vibration of the brake with the thermal effect is presented. These studies represent recent advances in the numerical studies of car brake squeal.

Mario Triches Junior, Samir N.Y. Gerges, Roberto Jordan (2008) [14] studied relation between braking pressure and squeal occurrence. The effect of braking pressure was introduced into the finite element model with the variation of the contact stiffness between the rotor and pads. The use of the stress–strain relationship method to determine this contact stiffness, allows an evaluation of the effect of the braking pressure on the contact stiffness. The braking pressure has an important effect in terms of defining the main unstable frequency. Basically, increase in braking pressure leads to a linear increase in the main unstable frequency. In some cases, the braking pressure leads to some other unstable frequencies, such as a pressure of 75 psi. This result concluded that for a high braking pressure the frequency where the noise occurs tends to be higher.

Franck Renaud, Gael Chevallier, Jean-LucDion, Guillaume Taudiere (2012) [15] found that the accelerations measured showed that the squeal frequency was dependent on brake pressure. Many authors have studied the phenomenon of squeal noise on simplified test rig. In this paper a squeal noise experiment was performed on a real brake system. Six three-axis accelerometers were fixed on the back plate of the piston pad. The spectrum of the pad's acceleration presented a fundamental frequency and two harmonics during squeal noise occurrence. These harmonics highlighted the non-linear nature of the squeal noise phenomenon. As the squeal fundamental frequency was present almost throughout the experiment, there is occurrence of squeal noise only audible when the harmonics emerged. Here, squeal could not be result of a stick–slip phenomenon. The authors assume that the nonlinear contact stiffness between pad and disc is a sufficient explanation for the harmonic rates observed. This assumption could be verified in future work by measuring the relative displacements between the pad and the other parts. The backplate motion of the piston pad was interpolated using the Finite Element method applied to acceleration measurements.

P. Liu, C. Cai, Y.Y. Wang, C. Lu, K.H. Ang, G.R. Liu [16] found that the effect of the hydraulic pressure on the squeal propensity. In this study pressure is varied from 0.5 MPa to 2.0 MPa. The major squeal frequency found is approximately 12 kHz. It is also found that with an increase in pressure, the value of the damping ratio is increased, so the squeal probability is increased. This is because larger hydraulic pressure increases more friction between the pads and the disc. However, the simulation results show that the effect of the hydraulic pressure on the disc brake squeal is not much significant because the value of the damping ratio only changes from 0.17 to 0.193 when pressure increases from 0.5 MPa to 2.0 MPa.

Yi Dai , Teik C. Lim (2007)[17] studied an enhanced dynamic finite element (FE) model with friction coupling is applied to study the design of disc brake pad structure for squeal noise. The FE model is developed from the individual brake component representations. The proposed friction coupling formulation model produces an asymmetric system stiffness matrix that gives a set of complex conjugate eigenvalues. From the analysis it is found that eigenvalues possessing positive real parts tend to produce unstable modes with the increased propensity of the generation of squeal noise. From the analysis beneficial pad design changes can be identified and implemented in the detailed FE model to find the potential improvements in the dynamic stability of the brake system. The best pad design attained, which produces the least amount of squeal response. It is finally validated by comparison to a set of actual vehicle test result. The friction coupling and brake pad study gives the following specific conclusions:

1. Shorter lining reduces the propensity of squeal.
2. Higher coefficient of friction increases squeal occurrences.
3. Various contact angles of pin-disc are most susceptible to squeal.
4. Higher damping in the brake system tends to decrease squeal. These design guidelines are then refined and used in the dynamic FE model to obtain a final pad design. The resultant design is then verified by using a set of vehicle level braking experiments.

D.W. Wang, J.L.Mo, H.Ouyang, G.X.Chen, M.H.Zhu, Z.R.Zhou (2014)[18] studied an experimental and numerical study of friction-induced vibration and noise of a system. In experimental study an elastic ball sliding over a groove textured surface was used. Results obtained from experimentation showed that the contact between the ball and the edges of the grooves highly reduce the generation of high frequency components of acceleration and reduce the friction noise. Groove-textured surfaces with a specific predefined dimensional parameter showed interesting characteristics in reducing squeal. To model and study this noise phenomenon, both the complex eigen value and dynamic transient analysis were performed. Results and conclusions from both the experimental and numerical can be made as follows:

1. Groove-textured surfaces with a specific dimensional parameter showed good characteristics in reducing and suppressing squeal in the experimental test.
2. The numerical model generated in this work can be effectively used to explain the effect of groove-textured surface on the friction, vibration and noise. The dynamic transient analysis for the cases of groove-textured surface further validates the role of impact between the ball and the groove edges.

Toru Matsushima, Kazuhiro Izui, Shinji Nishiwaki (2012)[19] in this paper there is modifications in brake components is studied. Disc brake squeal occurs due to the changes in unpredictable factors such as the friction coefficient, contact stiffness, and pressure distribution along the contact surfaces of the brake disk and brake pads. Author proposes a conceptual design method for disk brake systems that aims to reduce the occurrence of low frequency brake squeal at frequencies below 5 kHz. This is done by modifying the shapes of brake system components to obtain designs that are robust against changes in the above unpredictable factors. A design example is provided and the optimal solutions are validated using real-world experiments.

S. Oberst, J.C.S. Lai, S. Marburg (2013)[20] demonstrated that contact separation as observed experimentally and in analytical/numerical models is possible and could result in impact excitation of the rotor by the pad and an acoustic horn effect. It was found that for a simplified brake model using an annular disc, with a chamfered pad having reduced contact area is used in industries to reduce instabilities have an adverse effect on the acoustic radiation of a brake system. This study shows the importance of acoustic radiation as illustrated by the horn effect arising from chamfered pads and the importance of developing a proper understanding of contact dynamics including a realistic friction model.

J.L. Moa, Z.G.Wanga, G.X.Chen, T.M.Shao, M.H.Zhu, Z.R.Zhou(2013)[21] studied an experimental study on the effect of groove-textured surface on tribological behaviors and friction-induced vibration and noise properties. Conclusions obtained from the experimental results.

1. The squeal generated from the groove-textured surface was mainly affected by the dimensional proportion of groove width to pitch. In this work, groove-textured surfaces having specific dimensional proportion of groove width to pitch of 1/2 can effectively reduce squeal.
2. The squeal in this work was mainly caused by the local dynamics at the contact surface which excited a mode of the tribosystem.
3. There is no correlation between the value of friction coefficient and the generation of squeal.

Gottfried Spelsberg-Korspeter(2012)[22] showed analytically and experimentally that the stiffness properties of the disc are important. Splitting of double modes of the disc has a stabilizing effect. This knowledge is useful for structural optimization of brake rotors. Author explained experimental evidence for the relation of rotor asymmetry and squeal. It is shown that every elastic body with a cyclic symmetry with an angle less than Ω has at least one double eigen frequency. It makes susceptible to self excited vibrations, when operated as a rotor in frictional contact.

Choe-Yung Teoh, Zaidi Mohd Ripin, Muhammad Najib Abdul Hamid (2013)[23] studied that low sliding velocity is responsible for occurrence of squeal. Because low velocity is able to excite limit cycle of large amplitude vibration due to the alternately varying direction of friction forces. As coefficient of friction increases there is decrease in the critical value of sliding velocity. The increase in the braking load increases the critical value of sliding velocity and affects the limit cycle of the vibration. They have been developed a nonlinear two degree-of-freedom model of a drum brake system and verified experimentally.

P. Liu, C. Cai, Y.Y. Wang, C. Lu, K.H. Ang, G.R. Liu (2007)[24] found that as the angular velocity increases, the value of the damping ratio gradually decreases. Authors studied the variations in coefficient of friction within range 0.2-0.8 and effect of variance in coefficient of friction on contact interactions of disc and pad. Results are in the form of the damping ratio as a function of frequency for different friction coefficients. It is observed that the major squeal frequency is approximately 12 kHz. The value of the Damping ratio is decreased with a decrease of the coefficient of friction. It is also observed that with an increase in the friction coefficient, there is an accompanying increase in the instability of the system, thus an increase in the damping ratios. This shows that the squeal can be eliminated by reducing coefficient of friction between the pads and the disc. But, this obviously reduces braking performance and is not a preferable method to apply.

A. Akay, O.Giannini, F.Massi, A.Sestieri(2009) [25] studied All the numerical and experimental results related to the test rigs agree and can be observed to show that squeal is a dynamic instability driven by three factors:

1. The friction force is responsible for inducing asymmetry in the stiffness matrix. This is a characteristic exhibited by any friction law because friction couples together normal and tangential forces.
2. The increase of damping of the coalescing modes may increase the frequency range for which such has phase shift occurs, so that squeal can be suppressed, leading to a wide run stable range.
3. The role of damping cannot be neglected. Because it has experimental evidence that one can predict the presence of squeal in the braking system if damping is neglected.

Hugo Festjens, Chevallier Gael, Renaud Franck, Dion Jean-Luc, Lemaire Remy (2012)[26] studied the actual role of multi-layered viscoelastic parts, called as shims, to prevent squeal noises of automotive brake systems. This study explains the fact that shims are almost uniquely solicited in their normal direction in brake systems. Also the study focuses on the effect of added damping and stiffening induced by the viscoelastic materials. Finally, the study how certain Eigen modes for which the viscoelastic behavior of the shims explains instabilities that would not exist without damping shims.

Eskil Lindberg, Nils-Erik Hörlin, Peter Göransson(2012)[27]. A new experimental method for measurements of disc brake roughness noise is proposed, and is used in a lab environment where the vehicle speed and the brake pressure are accurately controlled. The aim is to study the influence of vehicle speed and brake pressure on the roughness noise inside the vehicle. It is shown for the specific test case that the transmission from the source to the interior is a vibro-acoustic structure-borne phenomenon. Measurements show that there is a, as expected, strong correlation between increased interior noise and both increased vehicle speed and brake pressure.

P. Liu, H. Zheng, C. Cai, Y.Y. Wang, C. Lu, K.H. Ang, G.R. Liu(2007)[28] used a new functionality of ABAQUS/Standard, which allows for a nonlinear analysis prior to a complex eigenvalue extraction in order to study the stability of brake systems, is used to analyse disc brake squeal. An attempt is made to investigate the effects of system parameters, such as the hydraulic pressure, the rotational velocity of the disc, the friction coefficient of the contact interactions between the pads and the disc, the stiffness of the disc, and the stiffness of the back plates of the pads, on the disc squeal. The simulation results show that significant pad bending vibration may be responsible for the disc brake squeal. The squeal can be reduced by decreasing the friction coefficient, increasing the stiffness of the disc, using damping material on the back plates of the pads, and modifying the shape of the brake pads.

Ma´rio Triche^s Ju´ nior, Samir N.Y. Gerges, Roberto Jordan(2008)[29] summarizes the application of complex eigenvalue analysis in a finite element model of a commercial brake system. The effect of the operational parameters (friction coefficient, braking pressure and brake temperature) and wear on the dynamic stability of the brake system is examined. After identifying unstable frequencies and the behavior of the brake system under different conditions, the performance of some control methods are tested. Changes in material properties and the application of brake noise insulators are presented and their effects discussed.

S. Oberst, J.C.S. Lai(2015)[30] done recent analyses using a forced response analysis with harmonic contact pressure excitation indicates negative dissipated energy at some pad eigen frequencies predicted to be stable by the CEA. A transient nonlinear time domain analysis with no external excitation indicates that squeal could develop at these eigen frequencies. Here, the acoustic radiation characteristics of those pad modes are determined by analysing the acoustic power levels and radiation efficiencies of simplified brake models in the form of a pad rubbing on a plate or on a disc using the acoustic boundary element method based on velocities extracted from the forced response analysis.

Manish Paliwal, Ajay Mahajan, Jarlen Don, Tsuchin Chu, Peter Filip(2004)[31] In the study, it is shown that the stiffness of the friction layer also plays a role in the system's behavior, as variation in its value may stabilize or destabilize the system. Hence its influence should be taken into account while studying the stick–slip motion of the brake system

Jaeyoung Kang, Charles M. Krousgrill,Farshid Sadeghi(2008)[32] The mathematical formulation for determining the dynamic instability due to transverse doublet modes in the self excited vibration of a thin annular plate is presented in this paper. An analytical approach is developed to obtain the stability results from the eigen value problem of a stationary disc with a finite contact area. The approach uses the eigen functions of transverse doublet modes in classical plate theory and establishes the formulation of modal instability due to the modal-interaction of a doublet mode pair. The one-doublet mode model of a disc and a discrete model equivalent to the one-doublet mode model are proposed for providing a more fundamental understanding of the onset of squeal. The analytical models are validated through a comparison of results from a modal expansion model obtained from finite element component models. Throughout the analytical investigation, the pad arc length is found to be a critical design parameter in controlling squeal propensity.

B. Ryzhik (2009) [33] The mechanism of excitation of friction-induced vibrations in a system comprising a flexible annular disk and two rigid surfaces is studied analytically. The surfaces are pressed together, and the rotating disk slides between them. It is shown that the sliding friction in the contact between the disk and the surfaces, together with the transverse contraction in the disk material, set up a feedback between the orthogonal eigenmodes of the disk corresponding to the same eigenfrequency, thus initializing instability. The instability mechanism is illustrated by simple analytical considerations. The obtained results are confirmed by finite-element analysis.

Daniel Hochlenert, Gottfried Spelsberg-Korspeter, Peter Hagedorn (2010)[34] Brake squeal is mostly considered as a comfort problem only but there are cases in which self-excited vibrations of the brake system not only cause an audible noise but also result in safety-relevant failures of the system. In particular this can occur if lightweight design rims having very low damping are used. Considering the special conditions of lightweight design rims, a minimal model for safety-relevant self-excited vibrations of brake systems is presented. It is shown that most of the knowledge emanated from investigations of the comfort problem can be used to understand and avoid safety-relevant failures of the brake system.

Valery Pilipchuk, Paweł Olejnik, Jan Awrejcewicz(2015)[35]

Non-stationary effects in the friction-induced dynamics of a two-degree-of-freedom brake model are examined in this paper.The belt–spring–block mode is designed to take into account variations of the normal load during the braking process. It is shown that due to the adiabatically slowing down velocity of the belt, the system response experiences specific qualitative transitions that can be viewed as simple mechanical indicators the onset of squeal phenomenon. In particular, the creep-slip leading to a significant widening of the spectrum of the dynamics is observed at the final phase of the process.

Jaeyoung Kang(2009)[36] In this paper, the dynamic instability of a car brake system with a rotating disc in contact with two stationary pads is studied. For actual geometric approximation, the disc is modeled as a hat-disc shape structure by the finite element method. From a coordinate transformation between the reference and moving coordinate systems, the contact kinematics between the disc and pads is described. The corresponding gyroscopic matrix of the disc is constructed by introducing the uniform planar-mesh method. The dynamic instability of a gyroscopic non-conservative brake system is numerically predicted with respect to system parameters. The results show that the squeal propensity for rotation speed depends on the vibration modes participating in squeal modes. Moreover, it is highlighted that the negative slope of friction coefficient takes an important role in generating squeal in the in-plane torsion mode of the disc.

Sung Soo Kim, Hee Jung Hwang, Min Wook Shin, Ho Jang (2011) [37] Automotive brake friction materials with four different abrasive particles were investigated. The abrasives used in this study were commercial grade silicon carbide, zircon, quartz and magnesia. The results showed that the fracture toughness of the abrasives played a crucial role in determining the friction level, wear debris formation and stick–slip. The friction material with silicon carbide exhibited a micro cutting mode with considerable stick–slip behavior, indicating a possible high propensity of noise occurrence during brake applications. On the other hand, the quartz and magnesia particles with low fracture toughness showed relatively small stick–slip amplitudes, suggesting that the fracture toughness of the abrasives can play important roles on the noise and vibration occurred during brake applications.

A. Akay, O. Giannini, F. Massi, A. Sestieri(2009)[38] This paper presents a review of recent investigations on brake squeal noise carried out on simplified experimental rigs. The common theme of these works is that of approaching the study of squeal noise on experimental set-ups that are much simpler than commercial disc brakes, providing the possibility of repeatable measurements of squeal occurrence. As a consequence, it is possible to build consistent and robust models of the experimental apparatus to simulate the squeal events and to understand the physics behind squeal instabilities.

Hui Lü, Dejie Yu(2016)[39] In this paper, a hybrid probabilistic and interval model is introduced to deal with the uncertainties existing in a disc brake system for squeal reduction. The uncertain parameters of the brake system with enough information are treated as probabilistic variables, while the parameters with limited information are treated as interval variables. To improve computational efficiency, the response surface methodology (RSM) is introduced to replace the time-consuming finite element (FE) simulations. By the hybrid uncertain model, an optimization design based on reliability and confidence interval is proposed to explore the optimal design for squeal reduction. In the proposed optimization, both the design objective and the design constraint are interval probabilistic functions due to the effects of hybrid uncertainties. The results of a numerical example demonstrate the effectiveness of the proposed optimization on reducing squeal propensity of the disc brake systems with hybrid uncertainties.

S.W. Yoon, M.W. Shin, W.G. Lee, H. Jang (2012) [40] Brake-induced stick–slip, which determines the propensity of a brake system to generate noise, was investigated by analyzing the friction oscillation at different loads, speeds, and surface topographies. The friction characteristics at the sliding interface were obtained using a pad-on-disk type tribometer and a 1/5-scale brake dynamometer. Results showed that the size and stiffness of the surface contact plate a us significantly affect the propensity of stick–slip and wear. The stick–slip amplitude increased with normal load and decreased with sliding speed. Contact stiffness of the friction material, which was modified by producing shallows lots on the rubbing surface, also strongly affected the stick–slip propensity, whereas Dm(¼ms_mk) was not changed by the surface modification. The strong effects from the contact stiffness suggest that the height distribution of the surface plate a us can change the stick– slip propensity of a brake friction material.

II. CONCLUSION

From this literature study various parameters affecting disc brake squeal are studied. Effect of increasing braking pressure leads to increase in disc brake squeal. It is found that lower rotational velocities have more probability to occur disc brake squeal. Higher coefficient of friction increase squeal propensity. Increase in damping reduces disc brake squeal. For elimination or reduction of disc brake squeal most important parameter is structural modifications in brake pad and disc.. Coefficient of friction cannot be reduced under certain limit as it affects braking performance. Additional damping reduces squeal propensity but it adds more cost to brake system. Structural modifications in disc and pad influence the disc brake squeal. So design modifications in braking system mostly disc and brake pad will save additional cost of damping.

III. FUTURE SCOPE

It is concluded that there is still much work needed to be done for understanding the mechanism of brake squeal noise. In addition, the further numerical and experimental investigations should be carried out using optimization methods in order to find the optimal design of the brake system.

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