Study of Determination of Automotive Brake Disc Thickness Variation

To analyses judder issue

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Abstract

Nowadays Vehicles are attractive more powerful and subsequent high speed. But due to road limitation rapid braking is also recurrent in RWUP condition and because of that minor variation in brake disc causes vehicle brake juddering and results in driver embarrassment & poor confidence. It is directly moving on business performance. Even though advanced technologies are available in market still it is incredible to calculated brake disc with zero variation. Vehicle juddering has become of major anxiety to automobile manufacturer world wide and braking performance not consistent due to brake disc variation. Brake Pad that will permit engineers to better understand the causes of DTV & Stick-slip the initiator of low & high frequency vibration in motor vehicle brake. DTV is caused by disc brake pad exhausting the brake disc, at their point of maximum run-out through repeated light rubbing whereas the brake of the vehicle is not applied, thus wearing two relatively solvent areas of the disc- one on each impression face- at completely opposite points.

Index Terms - Brake pressure variation, brake vibrations, cold judder, disc thickness variation, disc brake, hot judder.

I) Introduction

From earliest span vehicle judder caused by DTV has become major concern. Judder usually perceived by driver as minor to severe vibrations transferred through the chassis during braking [1-9]. Judder is classified into 2 types i.e. hot (thermal) & cold judder. Hot judder is result of longer more moderate braking from high speed where the vehicle does not come to a complete stop [13]. It occurs when we decelerate from speed of 120 km/h to about 60km/h, which results in severe vibrations being transmitted to the driver. These vibration results uneven thermal distributions believed to be the result of phenomena called hot spots. Hot spots are classified as concentrated thermal regions that alternate both the sides of the disc that distort it in such way that produces a sinusoidal waviness around at its corners. As brake pads comes in contact with sinusoidal surface during braking severe vibration are induced as a result and crate perilous situation for the person driving the vehicle [11,12,14-16].

Cold judder is result of uneven disc wear patterns or DTV. These variations in disc thickness are usually resulting of extensive vehicle road usage. DTV is ascribed to the following causes waviness of the disc, misalignment of the axis (run out), elastic deflection, thermal distortion, wear & thermal material transfers[3,15-17]. Whereas many companies are currently involved in research in this area, this is probably due to judder having inherent difficulties and the relative shortage of analytical model that can predict its behavior satisfactorily. Brake judder is a braking induced, compulsory vibration up in different types of vehicles. The judder occurrence is directly proportional to the revolt speed of the controls and therefore also to the rapidity of the vehicle. The driver knowledges judder as atmospheres in the steering controls, brake pedal and base. In the higher occurrence range, the mechanical atmospheres are convoyed by a sound. Brake judder primarily touches the relief but could, when challenging an innocent driver for the first time, lead to defective reactions and condensed powerful safety. Besides, a specific type of judder called hot judder, is related to disc rapid. There are numerous journals available industry with high frequency atmospheres, such as brake shriek, including mathematical models for examination and reproduction. Though, low frequency singularities, such as brake judder and growl, have received much less attention. There is a mounting attention from the automotive industry regarding brake judder. Even though few companies would acknowledge that they have the problematic, it is not uncommon to happen people who have knowledgeable the problematic in their own inside cars. Much of the knowledge regarding brake judder remainders within the companies.[5] Over the vehicle judder produced by Disc Thickness Variation (DTV) has developed of major anxiety to automobile constructers universal. Judder is usually apparent by the car driver as minor to simple vibrations moved complete the chassis throughout braking [1–9]. DTV is examined the usage of a Smart Brake Pad (SBP). The SBP is a tool that will allow engineers to improved appreciate the developments which occur in the exacting and limited atmosphere that exists between the brake pad and disc whereas braking. It is also a tool that will allow engineers to better appreciate the causes of DTV and stick-slip the inventers of low and high incidence vibration in motor vehicle brakes. Also, the technology can similarly be used to resolve many other still outstanding obscurities in automotive, aerospace or wherever where two exteriors may come in interaction.[21] The SBP consists of sensors fixed into an motorized brake pad permitting it to amount pressure among the brake pad and disc whereas braking. The two sensor technologies examined were Thick Film (TF) and Fiber Optic (FO) skills. Each type was tried independently using a Material Testing System (MTS) at room and preeminent temperatures. The selected SBP was then positively tested in replicated driving situations.[21]

A opening scientific model was established and tried for the TF sensor and a original Finite Element Analysis (FEA) for the FO sensor. An original technique called the Total Expected Error (TEE) method was also established to abridge the sensor requirement process to confirm reliable evaluations are made between sensors.

II) In works of DTV following Ideas are -

Types of Shuddering in Brake System- Shuddering in locomotive brake system is classified as per their leading frequency (Hz). It varies from low inflexible body judder vibration to high stick-slip self-enthusiastic vibration.

As apposed to lines, here, we will remain to use singularity rational metaphors such as judder, shriek etc.in the organization of vibrations inside brake organizations.[21]

Methods used to study DTV- Based on instrument and shuddering education, vibrations are very composite in nature therefore a number of different methods expressed to support investigator in the study of these singularities, namely reason, conclusion, system and occurrence sweep.

Reason Method- Cause of a singularity called Thermal Elastic Instability (TEI) is supposed to be the result of brake disc material indiscretions, such as Hot- Spots.

Conclusion - Application of this method is to study the paths of feelings takes from the foundation of the shuddering, through the vehicle chassis, to the driver [7].

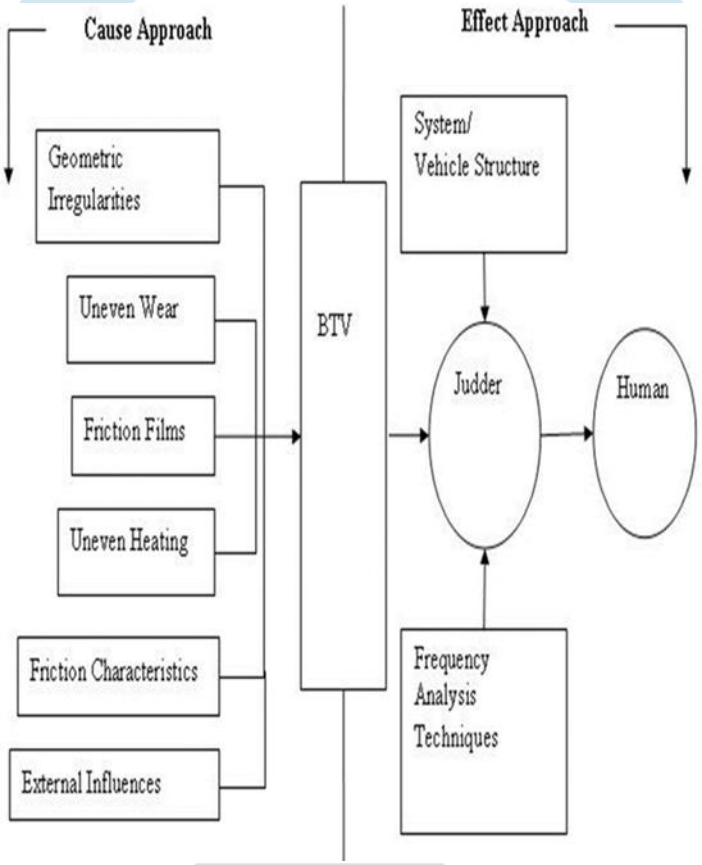

Figure1 - Reason and Conclusion [7]

System Method- With this method vehicle measured as one large system with numerous smaller sub systems. When it spread over to vehicle idea is to thoroughly examine the communications between the sub systems. For sample, Engel [3] functional the systems technique to the study of brake judder. In that examination, Engel studied the communication between the excitation and handover instruments that instigated brake judder [21].

Frequency Sweep Approach- This Approach comprises taking dimensions whereas the wheel speed is altering. Examination and dimension are made of judder at a constant speed; brake line heaviness and infection to streamline examination [7]. The frequency sweep approach similar the systems approach can be measured an result approach. It can also be supposed of as a sub-approach to be used inside one of before cited methods [21].

Now the reason approach will be used, as it is whispered that it is most significant not to disregard the origin cause of a problematic by looking at its result. Thus DTV will be examined as a likely reason of cold judder [21].

Reasons - DTV is classified as per how the uniform was shaped & it is of two types i.e. Off Brake wear (Off-BW) & On Brake wear (On-BW). OFF-BW DTV group is only because of jagged uniform which mains to judder [21]. The prospects for off-BW are as follows:-

i) Discs are installed with level of lateral runout; this runout will vary from car to car & design to design.

ii) The amount of caliper roll back is generally not enough to completely remove contact between friction material & disc whilst the brakes are in off brake condition.

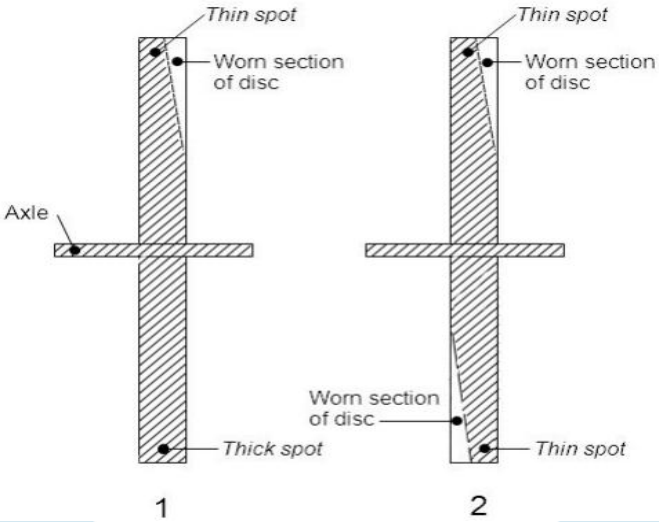

Figure-2) 1) Disc with one thin spot & 2) Disc with two thin spot[20]

iii) Whilst car is moving and brakes are in off brake condition, the disc comes in contact with friction material at the highest point of the lateral run out & disc gets worn away in this area.

The prospects for On-BW-

i) As friction material of pad is in contact with disc & on brake condition causes negligible uneven wear to the disc compared to off brake condition [18].

ii) During manufacturing, casting and machining operation can result waviness of the disc surface and errors in installation of wheels & bearing leads to DTV generation [18].

Properties: - These effects can be analyzed by two methods i.e. System method & Frequency Method.

System Method- Transfer of initial excitation from brake system through vehicle was most important factor[2]. We know that range of vibration for judder to occur is typically between 10-60 Hz & termed as low frequency vibration. Thus, resonance between that of the excitation mechanism and chassis must occur within this range. When vehicle is running at 95 km/h, natural frequency of the suspension has been found approximately 14 Hz[6] & brake disc excitation also comes in the same range.

Frequency Method- Cold judder seems to be the result of run out initiated DTV, the reason is that frequency of vibration at the critical speed is multiple wheel speed runout generate DTV with one thin section, would produce one pulse response per revolution. If the disc has two thinner sections, frequency would be double.

Disc and Resistance Material- Disc introduced in 1960 and discs are constructed by grey cast iron and having excellent wear properties & pads with asbestos friction material. Even today also grey cast iron is still used. In modern disc ingredients and machining processes are changed. Asbestos material has been deserted in most of the part of world because asbestos contained pads cause a fatal lung disease called asbestosis. Cast iron material were material designed to provide high thermal conductivity and the ability to withstand heating and cooling cycles and it also reduces hot spotting, thermal stress & no carbide formation. From last couple of year carbons fiber discs and their derivatives are being used for high performance motor vehicles particularly in racing at substantial cost. Now a day's introduction of environmentally friendly organic friction material has caused a re-emergence of hot spotting and judder.

Logical Techniques- Hohmann [19] uses the ADINA FEA package to analyze the contact conditions that may occur as a result of a stick-slip motion in brakes. The pressure distribution of contact area, are believed to be particularly important in the study of DTV [20].

III) Based on various actions are divided into-

Arrangement on Vehicle- In DTV dimension we measure inboard and outboard thickness reinvigorated runout (TIR), Disc Thickness variation (DTV) and exertion revolution of brake disc on the vehicle. For measurement, we requirement a motor-powered determined wheel drive connecter, two capacitive, non-contact researches and vertical contour beam laser.

DTV Dimension - DTV is dimension using brake disc micrometer and dial indicator are traditional technique.

Brake Disc Micrometer- it is particular micrometer calculated for this resolution. Its gullet bottomless will be deep sufficient to quantity disc thickness at numerous ideas transversely the disc. This instrument will have one or more pointed anvil instructions that allow you to quantity true thickness of the disc, starting at the bottom of any deep indentations. Quantity the disc thickness by design the propeller in at least 8 to 10 equally spread out intermissions. A disc that's in decent ailment shows differences in thickness of no more than 1 to 3 microns. There should be no more than 1 micron in difference between the understanding on new disc. The micrometer used for this is shown in fig 3 -

Figure-3 Brake Disc Micrometer

A micrometer for calculating the inside diameter of brake drums and the thicknesses of brake discs includes a standardized rod and a fixed cover member strictly attached to one end of said rod. An adaptable contact tittle having a machined contact surface at both ends is fiber capably affianced in the fixed cover member and is exchangeable mounted in a manually rotated dial. Standardizations on the dial parallel to the amount of rectilinear undertaking knowledgeable by the contact pin when the dial is interchanged. A transferable sleeve is also straddling on the standardized rod and carries a set screw for locating the sleeve on the rod by charming one of a row of regularly spaced holes drilled in the rod for this determination. Fixed contact pins carried by the portable sleeve are riding in axial arrangement with the adaptable contact pin on the fixed sleeve and point in conflicting instructions with respect to each other. Two sets of standardizations on the rod are in archive with the regularly spread out holes and resemble to the distances between the inner and outer contact surfaces of the changeable and fixed contact pins. Inside or outside distances may therefore be measured by first adjusting the calibrated dial to zero, introduction the suitable fixed contact pin in adjoining relative to the workpiece, regulating the portable sleeve to the closest conforming standardization on the rod and then revolving the adjusted dial to transport the inside or outside contact surface of the modifiable contact pin into appointment with the workpiece [23].

Dial Indicator- Interchange the pivot behavior assemblage by hand. Checked for roughness, performance or sound from bearing. The pivot is directly exaggerated by the complaint of the bearing. If a dial indicator dimension of bearing end performance is greater than 4 microns, the bearing is suspicious. A worn or movable wheel bearing will underwrite to pivot and disc runout. Set the dial indicator to zero, next try disc at minimum twice and detect the high and low plug of runout. Mark these spots on the disc. If disc shows runout greater than 50 microns or if the readings are unreliable curative action may be needed. Some unwell manmade disc may reach or exceeds this boundary with brand new. It working process is (fig 4) -

Figure-4) Dial Indicator with Brake Disc

Dial indicators can be defined as the small measuring instrument that can be used in several mechanical means to measure a certain deviation of a mechanical component. In terms of various components of a Dial indicator, it is made by pinions, levers as well as gears. Although, it can be declared that a dial indicator is mostly used by an operator for measuring the deviation of a linear surface.

DTV Data Analysis- Once DTV measurement data is acquired the next important parameter is analysis of this data. We acquired data in total 3 vehicles for both LH & RH side disc at Top, Bottom and Mid location. It shows that top side run out is higher than bottom side at each disc. And also, total thickness variation of disc at each location is within 5 microns in each vehicle (fig 5).

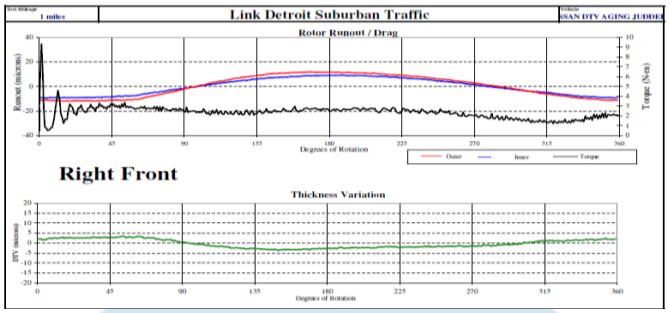

Figure-5) Disc Thickness Variation measurement for RH side at Disc Top

III) Effects

Universal Judder and shudder apprehension in automobile are minimize by monitoring the brake disc thickness variation & disc runout. This is consequential in protection vehicle management, enhanced driver self-assurance. Brake constancy at advanced rapidity. Recover automobile monitoring at high speed .

IV) Conclusions

The development and validation of brake disc is a great feat in engineering research. This paper will enable engineers to better understand the disc thickness and runout variation. This also enables engineers to better understand causes of DTV and stick-slip the initiator of low & high frequency vibration in brakes.

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