A Study on Malaysian Aftermarket Brake Pads Performance

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Abstract: Key performance requirements for brake pads include frictional stability and wear resistance. There were methods used for testing and one of the requirements include vehicle performance test. In this study, vehicle evaluation test was done on two brands of brake pads available in Malaysian market. The commercialized brake pads selected are fit for selected model vehicle, sold at low price and do not contain any approval information from any regulations. The sample were tested for cold performance testing, speed sensitivity testing, wear and micro structural analysis to identify the braking performance. The results were then compared with OEM brake pad composition. Both brake pads surpass the minimum regulations of UN R 90, with sample R1 exhibits closer performance with OEM compare to R2, but demonstrates higher wear loss. The results in this study provide useful indications on the safety level of brake pads sold in Malaysian market.

Key words: Brake pads · Speed sensitivity · Cold performance · Friction layer

INTRODUCTION

Brake pads serve an important role in braking system. A composite of brake pads consists of structural materials, matrix, filler, abrasives and lubricants, with each components plays different roles in braking performance. In order to achieve certain properties, the formulation of brake pads are continuously changed for improvement. The aim is to obtain preferable friction and wear regardless of environmental conditions. A considerable amount of literature has been published on the development on new formulations for brake pads [1-4]. Researchers have studied the effect of fibers [5-7], lubricants [8], resin [9-10], fillers [11] and abrasives [12] on the performance of brake pads. In 1995, Nicholson [13] reported that commercial brake friction materials have showed excellent wear and fade resistance through the optimization of formulation. During braking, a friction film is developed between brake pads and rotor disc through the rubbing process. New brake pads need to undergo a process called bed- in, behaviour attributed to the formation of third body film. The comprehensive study on third body formation has been discussed by Osterle & Urban [14] and Osterle et al [15]. Ertan & Yavuz [8] discovered that the friction film on brake pads was mainly affected by solid lubricant proportion. Cho et al [16] discussed that the morphology of potassium titanate plays an important role in the formation of contact films on the rubbing surface. Thus, each individual component in brake pads plays an important role in friction and wear characteristics.

Variety of brake pads are available in the market, either as original equipment manufacturer (OEM) or aftermarket (replacement) pads. As OEM products were tested thoroughly in order to ensure the compatibility with the whole vehicle system, not all of the aftermarket brake pads sold in Malaysia especially, tested according to the protocols. Fono-Tamo et al [17] investigated on wear properties of four aftermarket brake pads available in Nigerian market based on Weibull approached. The results showed that the overall experimental performance of Nigerian brake pads do not meet the specifications recommended by Standard Organization of Nigeria (SON). Furthermore, the comparative study done by Neis et al [18] in Brazilian market shows that out of three aftermarket brake pads tested, two brake pads performance were approved while aftermarket 3 could not achieve a minimum level of quality in terms of parameter analysed.

Based on the last study done on the brake pads [19], variety of aftermarket brake pads sold in Malaysia does not contain the approval of ECE R90 or MS. Referring to MS 1164:2015, Malaysian Standard is technically
equivalent to UN R90. The purpose of ECE R90 is to apply safety index procedure to compare relative safety of disc brake pads [20]. Regulations ECE R90 compare the performance of the original parts with those aftermarket pads in order to control the quality of the brake pads. The comparison test includes cold performance, plus speed sensitivity test. Brake pads that have been approved were marked with E marking, followed by the code of the country issuing the approval. ECE R90 also specifies that products are packaged in sealed, tamper-proof boxes before sale. The expensive costs of vehicle testing may prevent small-scale manufacturer’s to run the testing for approval purpose. The initial assumption in this study is, the low price of brake pads were due to the absence of vehicle brake performance test on the parts, in order to cut down the manufacturing cost. In 1971, Preston & Forthofer [21] reported that small-scale tests have the advantage of relatively low cost and shorter test times compared to the full brake system testing. As the E marking has proved that the brake pads performed as the performance of the original, the quality of the brake pads without E marking is being questioned. In addition, brake pads without E mark usually contain minimal information on the packaging, cause it harder for consumer to choose a better decision.

Most studies on the performance of brake pads tended to focus on dynamometer testing. To the best of author knowledge, the performance of brake pads on road were seldom conduct due to high cost. The objective of the study is to evaluate on road brake performance of commercial aftermarket brake pads sold in Malaysia. This report is important in order to ensure the current brake pads sold surpass the minimum requirements appointed by the regulations.

MATERIALS AND METHODS

Convenience sampling were done in Klang valley area, in order to study the price range of brake pads suitable for a model vehicle. Two brake pads without any approval marks, one represents foreign product (R1) while the other represents local (R2) and sold at the lowest price were selected for further vehicle performance testing. Tests were conducted according to UN Regulation 90 requirement. Original (OEM) brake discs of the vehicle model was used for the vehicle test and condition of tyres were prepared according to regulation. For comparison purpose, the selected brake pads together with OEM as reference undergo two major parts of UN R 90 components, cold performance and speed sensitivity testing. Cold performance comprises the effect of increasing brake pedal on brake deceleration through slightly above normal temperature while speed sensitivity investigates the consistency of brake deceleration through different speeds. The speed, stopping distance and deceleration were recorded using HKM Pedal Fore PK-PKH. The thickness of brake pad samples were taken before and after the vehicle performance test. Three measurements were taken at different spots on the samples in order to obtain the average thickness value. The microscopic images of worn surfaces were obtained using scanning electron microscopy (SEM). Scanning electron microscope equipped with energy dispersive X-ray spectroscopy (EDX) is used to characterize the pad surface heterogeneity together with compound size and morphology.

RESULTS AND DISCUSSION

The pie chart in Figure 1 classified the brake pads based on the price range. At first glance it can be seen that nearly half (46%) of the studied brake pads are sold within price of MYR50 to MYR 100. Brake pads sold within price of MYR 100 to MYR 150 represents just over a quarter from the total. Furthermore, the brake pads sold over MYR 200 has the lowest percentage in the chart respectively. It is quite interesting to note that out of 200 samples surveyed, only one brake pad contains local certification. R1 and R2 were selected within the price of MYR 0-50 and retail as the cheapest among others.

On Road Performance Testing: The result of cold performance test was shown in Figure 2. The dotted line presented the upper and lower limit of MFDD value for each brake force application. Firstly, it can be seen that both R1 and R2 comply the requirement and generate MFDD value within ±15 per cent of the OEM brake pads. Under Annex 3 paragraph 2.1.1.2 it has been stated that MFDD of front axle brakes should achieve 5m/s², which both R1 and R2 attained. Particularly, R1 shows close resemblance to OEM performance, which means that the pads performance of R1 at different pressures are more consistent. Sundarkrishnaa [20] indicated that the lower the variation, the more consistent the pad performance at different pressures will be. During testing, OEM shows increment of MFDD as the pedal force increased (except at 40 daN). However, MFDD for R2 decreased during 25 daN, 40 daN and 50 daN pedal force.
Fig. 1: Brake pad price distribution

Fig. 2: Cold performance testing results

The requirement is slightly different for speed sensitivity test. MFDD recorded for higher speeds shall lie within 15 percent of that recorded for the lowest speed. The purpose of conducting speed sensitivity test is to study the extent of stability in MFDD with respect to changes in speed levels. Both R1 and R2 comply with minimum requirements of UN R 90. The lowest variation was detected in R1, followed by R2 and OEM. The lower the variation, the smallest adjustment with respect to pedal pressure that the driver will need to make to obtain the same rate of deceleration. Data plotted in Figure 3 clearly show that R2 displays dissimilar pattern compared to OEM and R1. In both OEM and R1, the MFDD value increase with the increase in speed. However, MFDD in R2 increase abruptly during 100km/h, then reduce during 135km/h testing.

Fig. 3: Speed sensitivity results

Thickness Loss and Wear of Brake Pads: The wear is expressed by thickness variations of brake samples before and after completing the vehicle testing. Comparing the three brake pads, the highest wear was observed from sample R1 (9.74%), followed by R2 (7.30%) while in contrast, OEM exhibits lowest thickness loss with 3.32%. The thickness loss should be attributed to different type, size, shape and weight percentage of elements used in the compositions, including the friction layer of tested brake pads. Talib et al [22] discussed that average thickness loss are not directly dependent on the fade temperature, but could be considered as dependent on the organic composition of the brake pads. R1 showed substantially higher wear than R2 and OEM and from wear point of view, OEM performs the best. The research study by Neis et al [23] also found that the thickness reduction for NAO brake pads is lower than semi metallic brake pads after testing. This may be contributing and influence by inclusion of Cu in OEM. In addition, the smaller size and shape of constituents in OEM brake pads helps in minimizing thickness loss of brake pads. R1 exhibits the lowest wear resistance, followed by R2. This is associated to its higher contents of metallic fibers. The finding is consistent with the study done by Kumar & Bijwe [24], where it is revealed that the bigger size of the fibers and the larger amount (20 wt%) is responsible for their easy removal from the pad surface.

Morphological Changes on the Worn Surface of Brake Pads: Figure 4 presents the SEM of worn surface brake pads. The difference observed in between surface of brake pads before and after testing was the presence of friction layer that formed on the surface of all brake pads tested and covers a large part of the worn surface in grey contrast [25]. The presence of friction layer (Figure 4a) are visibly prominent in OEM brake pads. OEM brake pads features a smooth topography with least damage and very good adhesion of ingredients with the matrix and friction layer. EDX analysis on sample OEM shows the addition
of Fe element, which apparently transfers from brake disk. Other elements found on wear OEM brake pads includes the presence of Cu and carbonaceous components. In another study done by Osterle and Urban [26], it was found that the wear product of copper and brass seems to adhere more tightly to the substrate whereas iron oxides are more prominent in the loose wear particles. Thus, it may explain why OEM has the best wear performance within the three samples tested.

The worn surface of R1 is shown in Figure 4(b). There is evidence of protruding fibers on the worn surface and greater presence of secondary plateaus compare to OEM. The plateaus and evidence of micro-cracks were responsible for high wear of this composites, compare to R2 and OEM. EDX analysis on the secondary plateaus shows a high amount of iron oxide, magnetite, magnesia, barium sulphate and calcium carbonate. Magnetite as a friction modifier help stabilizing COF [27] and this can be seen from the result during speed sensitivity test, where R1 performs the best.

While the evidence of contact surface were much more dominants in sample OEM, followed by R1, the contact evidence in R2 was much lesser. It can be observed that worn surface morphology is significantly differing for R2 brake pads. Close studies on Figure 4(c) shows that the friction layer does not cover all the entire worn surface and there was presence of surface cracks. It is clear in R2 that the fibers get deboned from the surface and stay intact with the friction interface. Some damage on the surface and worn piece of fibers was due to weak adhesion between metallic fiber and resin. The loosely bonded fibrous fraction may have attributed to the poor braking performance of R2 compare to OEM and R1.

CONCLUSION

Two commercial brake pads with lowest price in the market for selected model vehicle were tested and compare to friction performance of OEM. The brake pads selected do not contain any approval marks from any test protocols or regulations. Cold performance testing and speed sensitivity testing were carried out through vehicle-level testing. The following points emerged from the present investigation:

- The tests result show that both REM1 and REM2 surpass the minimum requirement of UN R90 for aftermarket brake pads.
- In particular, REM1 produced average MFDD that was closed to performance of OEM in cold performance test compare to REM2.
- Similarly, for speed sensitivity test, REM1 shows lowest variation between MFDD values during application of 135km/h with MFDD during application of 65km/h.
- Conversely, REM1 exhibits the highest thickness loss compare to REM2 and OEM, suggesting shorter service life.
The finding of the present study suggests that the brake pads sold at minimum price in the market do comply with UN R 90 comparison testing requirement, however the wear performance might not up to par. The study has gone some way towards our understanding of the high variation of brake pads price in Malaysian market and the urgency of strict regulations in brake parts products. The purpose of this study did not represent any product endorsement nor any attempt to prove which materials had either excellent or poor characteristics. The present study explores the safety of brake pads that are sold in the market at lowest prices. UN R 90 and Malaysian Standard MS 1164 should be used as minimum requirement for aftermarket to ensure the quality of commercial aftermarket is as par as the original brake pads.

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REFERENCES


