ABSTRACT

The formulation of a brake pad requires the optimization of multiple performance criteria. These include achieving a consistent and adequate coefficient of friction ($\mu$), low wear and minimizing its sensitivity to the brake operating parameters in order to produce low fade and high recovery characteristics.

Among the various properties, resistance to fade is difficult to achieve. In non-asbestos organic (NAO) brake pads, resin, friction dust and some organic fibers that are most vulnerable to thermal degradation undergo charring which results in glazing and deterioration in friction performance. Hence the influence of these ingredients in the brake pad was studied individually and the same were optimized.

Key characteristics of phenolic resin are its molecular weight distribution as it has significant effect on the end use. Characterizing and understanding the molecular weight distribution of resin materials is therefore essential to their performance. Currently there is no unified understanding of exactly how the intrinsic properties (like molecular weight, cross-link density) of the resin affect the resultant mechanical performance. Hence three brake pads with distinct molecular weight ($M_w=2412, 4544 \& 5223$) designated as FCL, FCM and FCH were fabricated and tested for the friction and wear. It is found that FCM (Friction composite with $M_w 4544$) showed considerable amount of fade resistance coupled with good recovery characteristics. The consistent friction level is found to be due its property in between highly rigid and too flexible, which maintains the real area of contact and found to be
useful upto 344°C. Hence the resin with medium molecular weight FCM ($M_w$ 4544) is considered suitable for further study.

In addition, the type and amount of resin in the brake pad is very critical. If the resin amount is too less it results in material weakness and if too much is used then there is a friction drop at high temperatures. Right amount of resin imparts adequate integrity to the brake pad without sacrificing other important properties. Hence three brake pads (DBL(10.11%), DBM (11.11%) & DBH(12.11%)) were fabricated by varying only the weight percentage of resin in the formulation and tested in an Inertia brake dynamometer. It is observed that DBH imparts unacceptable fade. DBL was found to be superior than DBM with respect to Fade, recovery and less temperature rise. However, DBL has poor wear resistance than DBM. Since, safety comes first than wear, DBL is considered to be better than DBM & DBH. It is also observed that the increase in resin content reduced the thermal stability but increased the frictional stability.

The other organic ingredient namely cashew friction dust was also optimized along with the resin and tested in the dynamometer. Response surface methodology was carried out as two parameters have to be optimized from the test results. RSM indicates the optimum percentage of resin and friction dust (10.11 wt% of resin and 9.33 wt% of friction dust), which is in agreement with the test results Regression analysis was also carried out to study the sensitivity of $\mu$ to the operating variables namely pressure and speed. Speed was observed to be a more dominant parameter, which influenced the $\mu$ rather than the pressure.

Organic fibers namely aramid, cellulose and acrylic fibers were chosen considering the cost factor and easiness in manufacturing. Three brake
pads were fabricated (designated as NA01, NA02 and NO 03) by varying these organic fibers and frictional characteristics and wear were discussed. It is observed that increase in fiber content (in the case of NA 01) increased the thermal stability. Also the increase in thermal stability paved way for the frictional stability contrary to the study carried out in the resin optimization. Wear is also reduced due to more amount of secondary plateaus formation due to the additional fiber content.

Overall, the influences of the organic ingredients were studied with respect to thermo-physical and tribo-properties of Non asbestos disc brake pad and the same were optimized.